Winter 12-18-2018

The Effect of Mandating Algebra for all Students in Grade 8 versus Grade 9 in a Small Suburban K-12 School District in New Jersey

Peter Crawley
pcrawley@flboe.com

THE EFFECT OF MANDATING ALGEBRA FOR ALL STUDENTS IN GRADE 8 VERSUS GRADE 9 IN A SMALL SUBURBAN K-12 SCHOOL DISTRICT IN NEW JERSEY

BY

Peter Crawley

Dissertation Committee

Martin Finkelstein, Ph.D., Mentor
Gerard Babo, Ed.D.
Sharon Amato, Ed.D.

Submitted in partial fulfillment of the requirements for the degree

Doctor of Education

Department of Educational Leadership, Management and Policy

Seton Hall University

September 2018

SETON HALL UNIVERSITY
COLLEGE OF EDUCATION AND HUMAN SERVICES
OFFICE OF GRADUATE STUDIES

APPROVAL FOR SUCCESSFUL DEFENSE

Peter Crawley, has successfully defended and made the required modifications to the text of the doctoral dissertation for the **Ed.D.** during this **Fall Semester 2018**.

DISSERTATION COMMITTEE
(please sign and date beside your name)

Mentor: Dr. Martin Finkelstein		9/17/2018
Committee Member: Dr. Gerard Babo		9/17/18
Committee Member: Dr. Sharon Amato	Dr. Sharon Amato	9.17.18

The mentor and any other committee members who wish to review revisions will sign and date this document only when revisions have been completed. Please return this form to the Office of Graduate Studies, where it will be placed in the candidate's file and submit a copy with your final dissertation to be bound as page number two.

ABSTRACT

THE EFFECT OF MANDATING ALGEBRA FOR ALL STUDENTS IN GRADE 8 VERSUS GRADE 9 IN A SMALL SUBURBAN K-12 SCHOOL DISTRICT IN NEW JERSEY

The traditional sequencing of the ninth- to twelfth-grade math curriculum in the United States has students taking Algebra 1 in the ninth grade, Geometry in the tenth grade, Algebra 2 in the eleventh grade and an optional advanced math course (e.g. pre-calculus, statistics) in the twelfth grade. In this traditional setup, talented math students are given the opportunity to take Algebra 1 in the eighth grade, which allows them to take two or more years of advanced math before graduating from high school. In an effort to create more equitable access to advanced math courses, many districts are considering or have implemented policies that encourage or require more students to take Algebra 1 in the eighth grade. This study examines one such policy in the Fort Lee Public School district, which implemented mandatory enrollment in Algebra 1 for all regular-education, eighth-grade students in the 2015–2016 school year. The study examines two cohorts of students: the 2015–2016 eighth graders who were the first to experience compulsory enrollment in Algebra 1 in the eighth grade and the 2014–2015 eighth graders who were the last group of students to enroll in the traditional math sequence, and who therefore did not take Algebra 1 until the ninth grade. Two primary research questions guided the study in examining how the policy affected students' performance in Algebra 1 and how the policy affected their performance in Geometry. Several sub-questions addressed specific demographic groups, including black and Hispanic students, economically disadvantaged students, and males and females. Course performance was measured using students' scale scores on the Partnership for Assessment of Readiness for College and Careers (PARCC) course assessment for Algebra 1 and Geometry. A hierarchical regression analysis was run on the cohorts and subgroups in order to identify the effect of the policy when controlling for other exogenous variables including attendance, prior performance, race, socioeconomic status and gender. The results of the study revealed that exposure to the policy had a minimal effect on the cohorts as a whole and no effect on the majority of subgroups included, indicating that students had been successfully accelerated through the curriculum without undermining their mastery of foundational coursework. This research can inform policymakers' decisions with regard to a policy requiring that all eighth-grade students take Algebra.

Keywords: Algebra 1, Geometry, PARCC, curricular intensification, curricular acceleration, advanced math

ACKNOWLEDGMENTS

I would like to start by thanking all of the faculty and staff who manage, support and teach in the Seton Hall Executive Ed.D. Program. The guidance, instruction and curriculum that you have offered throughout this experience has provided me not only with the skills and knowledge required to complete my dissertation, but has also been a tremendous source of professional development that has made me a better school administrator. The activities and discussions I have participated in both in and out of class have allowed me to gain tremendous perspective on how education works outside of what I was familiar with, having worked only in public schools in New Jersey. I would like to thank my fellow members of Cohort XX who provided an incomparable support system, without which the successful completion of my doctorate would have been impossible.

I will always be grateful for my dissertation committee, which consisted of three veteran educators who each provided a unique lens that developed and improved my dissertation.

To my mentor, Dr. Finkelstein, I am truly grateful for your support throughout this process and your willingness to provide prompt and meaningful feedback on my work. Your availability for phone calls and e-mails made this process smooth, allowing me to never lose faith that, while this was a huge project to complete, it always felt within reach.

To my committee member, Dr. Babo, your guidance and assistance throughout this process has been invaluable. In particular, your ability to explain how complex statistical analysis can be applied to my work made this process much more manageable. As with Dr. Finkelstein, I could not have completed this dissertation without your accessibility and direct, meaningful feedback.

To my committee member and boss, Dr. Sharon Amato, I owe a large portion of my successful completion of this dissertation and the Executive Ed.D. program to your support and guidance throughout the process. As a program veteran, the advice and resources you have shared with me over the past two and a half years have been integral in focusing me and keeping me moving toward my goal. I would be remiss if I did not also thank you for your professional support. From giving me my first shot in K-12 administration to providing me with support and guidance in the early stages of my career, you have provided me with a structure in which I could be successful and grow as a leader in education. You have been a tremendous boss and colleague over the past three and a half years.

To my fellow members of the curriculum department in Fort Lee, Michele Carlor and Diane Baker, as well as the rest of the wonderful Fort Lee administrative team, you make coming to work a pleasure each day. I owe, in large part, my successful completion of this program and dissertation to the fun and challenging environment that I work in. Working full time and completing a doctoral program could easily have burned someone out were it not for such a positive professional environment.

DEDICATION

This dissertation is dedicated to my family, who provided me with the support and patience necessary to complete this program.

To my amazing wife Kathryn, thank you for having my back throughout this process. I know the innumerable days spent out of the house working on my assignments and dissertation were trying, but your patience made the dissertation's completion possible. It was always difficult spending weekends in class or at the library writing papers instead of being with the boys, but knowing they were at home with the best mother anyone could ask for always gave me comfort. I love you and thank you.

To my sons, Danny and Will, my two best friends who keep me grounded and give me perspective on what is important in life every moment I spend with you. You both have been my inspiration to complete this program. Although you will likely be too young to remember this, I will always be grateful for your tolerance of the hours of work that went into this. The hugs and kisses I got every time I got home from class or writing helped kept me going.

To my mom, Karen Crawley, who was the first person who knew I would be a teacher. I should have listened when you told me to look into an education major as an undergraduate, but the stubborn 19-year old in me thought otherwise. It only took one month after graduating for me to be in class working toward my teaching license and striving to join the family business. You have been such a wonderful mother to me and grandmother to my boys. Completing this program would have been unimaginable without the lifelong support you have given to me.

To my dad, Thomas Crawley, Ed.D., although you are not on my committee, you have been the most important mentor and guiding force academically, professionally and personally.

If I am able to look back on my education, career and family and say I did half as good a job as you did, I will consider all three tremendous successes. Thank you for everything.

Contents

Chapter I 1
INTRODUCTION AND BACKGROUND 1
Introduction to the Research Problem 2
Delimitations 3
Purpose 4
Significance of the Study 7
Hypothesis 7
Definition of Key Terms 8
Chapter II 10
REVIEW OF THE LITERATURE 10
Introduction 10
Algebra in the Eighth Grade 10
Tracking and Detracking 12
Advanced Math in High School 15
Exogenous Factors Related to Math Achievement 16
Chapter III 20
METHODOLOGY 20
Dominant Research Method 20
Specific Design 20
Potential Population 21
Recruitment and Selection of Subjects 22
Instruments and Data Collection 26
Data Validity and Reliability 26
Protection of Subjects 27
Status of Variables 27
Analytical Model 27
Analysis 31
Chapter IV 38
ANALYSIS OF THE DATA 38
Introduction 38
Research Questions 38
Reporting of Results 40

Summary of Findings 41
Procedure 46
2016 Algebra 1 PARCC Assessment 47
Full Cohort Analyses 48
Economically Disadvantaged Analysis 57
Black and Hispanic Analyses 65
Female Analysis 74
Male Analyses 82
2017 Geometry PARCC Assessment 90
Full Cohort Analyses 91
Economically Disadvantaged Analyses 100
Black and Hispanic Analyses 106
Female Analyses 113
Male Analyses 122
Summary of Findings 130
CHAPTER V 136
CONCLUSIONS AND RECOMMENDATIONS 136
Introduction 136
Research Questions and Answers 137
Research Question 1 137
Answer 137
Research Question 2 139
Answer 139
Research Question 3 140
Answer 141
Research Question 4 142
Answer 142
Research Question 5 143
Answer 143
Conclusions: Effect of Treatment on Algebra 1 Performance 144
Research Question 6 145
Answer 145

Research Question 7 146
Answer 146
Research Question 8 147
Answer 147
Research Question 9 148
Answer 148
Research Question 10 149
Answer 149
Conclusions: Effect of Treatment on Geometry Performance 150
Recommendations for Policy 151
Recommendations for Practice 153
Recommendation for Future Study 154
Conclusion 156
REFERENCE LIST 158
APPENDIX A – ANOVA Table (Research Question 1) 162
APPENDIX B – ANOVA Table (Research Question 2) 163
APPENDIX C – ANOVA Table (Research Question 3) 164
APPENDIX D – ANOVA Table (Research Question 4) 165
APPENDIX E – ANOVA Table (Research Question 5) 166
APPENDIX F – ANOVA Table (Research Question 6) 167
APPENDIX G – ANOVA Table (Research Question 7) 168
APPENDIX H – ANOVA Table (Research Question 8) 169
APPENDIX I – ANOVA Table (Research Question 9) 170
APPENDIX J – ANOVA Table (Research Question 10) 171
APPENDIX K – IRB Approval 172

List of Tables

Table 1: Algebra 1 Sample Size 25

Table 2: Geometry Sample Size 26

Table 3: Full Names and Shortened Labels of all Variables 44

Table 4: Racial Breakdown of Cohorts 45

Table 5: Socio-Economic Status Breakdown of Cohorts 46

Table 6: Gender Breakdown of Cohorts 46

Table 7: Prior Achievement Breakdown by Cohort 46

Table 8: Attendance by Cohort 46

Table 9: Descriptive Statistics T_1 (Algebra) 48

Table 10: Descriptive Statistics T_0 (Algebra) 49

Table 11: Full Cohort Group Statistics (Algebra) 49

Table 12: Full Cohort Independent Sample T-Test (Algebra) 49

Table 13: Full Cohort Variables (Algebra) 51

Table 14: Full Cohort Model Summary (Algebra) 52

Table 15: Full Cohort Coefficients (Algebra) 54

Table 16: Economically Disadvantaged T_1 Descriptive Statistics (Algebra) 58

Table 17: Economically Disadvantaged T_0 Descriptive Statistics (Algebra) 58

Table 18: Economically Disadvantaged Group Statistics (Algebra) 59

Table 19: Economically Disadvantaged Independent Sample T-Test (Algebra) 60

Table 20: Economically Disadvantaged Variables (Algebra) 61

Table 21: Economically Disadvantaged Model Summary (Algebra) 62

Table 22: Economically Disadvantaged Coefficients (Algebra) 63

Table 23: Black and Hispanic T_1 Descriptive Statistics 66

Table 24: Black and Hispanic T_0 Descriptive Statistics (Algebra) 67

Table 25: Black and Hispanic Group Statistics (Algebra) 68

Table 26: Black and Hispanic Independent Sample T-Test (Algebra) 68

Table 27: Black and Hispanic Variables (Algebra) 69

Table 28: Black and Hispanic Model Summary (Algebra) 70

Table 29: Black and Hispanic Coefficients (Algebra) 71

Table 30: Female T_1 Descriptive Statistics Algebra 74

Table 31: Female T_0 Descriptive Statistics (Algebra) 75

Table 32: Female Group Statistics (Algebra) 75

Table 33: Female Independent Sample T-Tests (Algebra) 76

Table 34: Female Variables (Algebra) 77

Table 35: Female Model Summary (Algebra) 78

Table 36: Female Coefficients (Algebra) 79

Table 37: Male T_1 Descriptive Statistics (Algebra) 82

Table 38: Male T_0 Descriptive Statistics (Algebra) 83

Table 39: Male Group Statistics (Algebra) 83

Table 40: Male Independent Sample T-Test (Algebra) 84

Table 41: Male Variables (Algebra) 85

Table 42: Male Model Summary (Algebra) 86

Table 43: Male Coefficients (Algebra) 88

Table 44: Full Cohort T_1 Descriptive Statistics (Geometry) 91

Table 45: Full Cohort T_0 Descriptive Statistics (Geometry) 92

Table 46: Full Cohorts Group Statistics (Geometry) 93

Table 47: Full Cohorts Independent Sample T-Test (Geometry) 93

Table 48: Full Cohorts Variables (Geometry) 94

Table 49: Full Cohorts Model Sumary (Geometry) 95

Table 50: Full Cohorts Coefficients (Geometry) 97

Table 51: Economically Disadvantaged T_1 Descriptive Statistics (Geometry) 101

Table 52: Economically Disadvantaged T_0 Descriptive Statistics (Geometry) 102

Table 53: Economically Disadvantaged Group Statistics (Geometry) 103

Table 54: Economically Disadvantaged Independent Sample T-Test (Geometry) 103

Table 55: Economically Disadvantaged Variables (Geometry) 104

Table 56: Economically Disadvantaged Model Summary (Geometry) 105

Table 57: Black and Hispanic T_1 Descriptive Statistics (Geometry) 106

Table 58: Black and Hispanic T_0 Descriptive Statistics (Geometry) 107

Table 59: Black and Hispanic Group Statistics (Geometry) 108

Table 60: Black and Hispanic Independent Sample T-Test (Geometry) 108

Table 61: Black and Hispanic Variables (Geometry) 109

Table 62: Black and Hispanic Model Summary (Geometry) 110

Table 63: Black and Hispanic Coefficients (Geometry) 111

Table 64: Female T_1 Descriptive Statistics (Geometry) 113

Table 65: Female T_0 Descriptive Statistics (Geometry) 114

Table 66: Female Group Statistics (Geometry) 115

Table 67: Female Independent Sample T-Test (Geometry) 115

Table 68: Female Variables (Geometry) 116

Table 69: Female Model Summary (Geometry) 118

Table 70: Female Coefficients (Geometry) 119

Table 71: Male T_1 Descriptive Statistics (Geometry) 122

Table 72: Male T_0 Descriptive Statistics (Geometry) 123

Table 73: Male Group Statistics (Geometry) 123

Table 74: Male Independent Sample T-Tests (Geometry) 124

Table 75: Male Variables (Geometry) 125

Table 76: Male Model Summary (Geometry) 126

Table 77: Male Coefficients (Geometry) 127

Table 78: 2015-2016 Algebra PARCC Performance Standardized Betas for Significant Variables* 131

Table 79: 2015-2016 Algebra PARCC Performance Percent of Variance Explained by Variable* 132

Table 80: 2016-2017 Geometry PARCC Performance Standardized Betas for Significant Variables 133

Table 81: 2016-2017 Geometry PARCC Performance Percent of Variance Explained by Variable 134

Table 82: Reported Results for Research Question 1 137

Table 83: Reported Results for Research Question 2 139

Table 84: Reported Results for Research Question 3 141

Table 85: Reported Results for Research Question 4 142

Table 86: Reported Results for Research Question 5 144

Table 87: Reported Results for Research Question 6 146

Table 88: Reported Results for Research Question 8 148

Table 89: Reported Results for Research Question 9 149

Table 90: Reported Results for Research Question 10 150

Chapter I

INTRODUCTION AND BACKGROUND

The practice of detracking, or ending policies that group students into courses by ability, is a progressive approach implemented by many school districts (Burris & Garrity, 2008). The practice of tracking has been criticized as having the unintended result of re-segregating integrated schools by tracking students of color and lower socioeconomic classes in "lower" sections (Rubin, 2003). Detracking has taken on several forms, including comprehensive detracking of all courses, systematic detracking of academic courses that begin with a specific grade level and move up as students advance, and detracking of specific courses (Corbett & Garrity, 2008). One popular form of detracking is the adoption of early universal Algebra policies (Howard, Scott, Romero, & Saddler, 2015). Algebra has long been considered a "gateway" course to college-level math, and research has demonstrated that students who do not have a strong foundation in the concepts taught in Algebra have a lower chance of succeeding in college (Snipes & Finkelstein, 2015). The thought behind a universal policy implementing Algebra in eighth grade is that it can expose more students, particularly those who were formally tracked in lower levels and therefore did not take Algebra in high school, to a more complex and rigorous math curriculum. Those students who pass the course early have the opportunity to take more advanced math courses in high school, while those who do not pass the course in eighth grade have an extra year to remediate their skills (Snipes & Finkelstein, 2015). Eighth-grade Algebra was typically limited to students in the "high" or "advanced tracks," so these policies serve to simultaneously de-track and increase the rigor of the mathematics curriculum. This study examines the effect of a policy regarding Algebra in eighth grade on students in Fort Lee

Public Schools in terms of both performance in Algebra as well as performance in future math courses.

Introduction to the Research Problem

Fort Lee Public Schools refers to a small, suburban district of approximately 4,000 students. The families in the district of Fort Lee consist primarily of white-collar workers who take advantage of the town's location at the foot of the George Washington Bridge. The district is 46.1% Asian, 28.5% white, 20.0 % Hispanic, 4.1% black or Hispanic, 1% two or more races, 0.2% native Hawaiian or pacific islander, and 0.1% American Indian or Alaskan native. The district consists of 48% female and 52% male students. Nineteen percent of the students in the district are enrolled in the free and reduced lunch program and are therefore classified as economically disadvantaged. Thirteen percent of the students have been classified as students with disabilities, and 12% are English-language learners. There are six schools in the district: four elementary schools, with grades Pre-K through 6; one middle school, with grades 7 through 8; and one high school. The district is high performing: the high school is ranked 55 in the state of New Jersey and regularly sends students to Ivy League and other comparable colleges and universities.

Prior to the 2015-2016 school year, Fort Lee Public Schools had what would be considered a traditional sequence of math courses. Students would take grade-level math (Math K, Math, 1, Math 2, etc.) through the eighth grade. Math 8 was designed as a Pre-Algebra course to prepare students for high-school level math courses. The majority of students would take Algebra 1 their freshman year of high school, Geometry their sophomore year, Algebra 2 their junior year, and a math elective or no math course their senior year. Approximately the lowest

60% of students, in terms of teacher recommendations, scores on standardized tests, and final course grades, took this sequence of courses. It was those between the 61st and 95th percentile approximately who were tracked into Pre-Algebra in the 7th grade, accelerating their courses to take Algebra in eighth grade and have an opportunity to take two math electives in high school (junior and senior year). The top 5% of a class was enrolled in an even more accelerated sequence, which allowed them to forego Pre-Algebra and take Algebra and Geometry in the seventh and eighth grades, respectively. These students would take one core math course (Algebra 2) in high school and could use the remaining three years to take math electives, including courses with college credit through the AP and IB programs.

During the 2014-2015 school year, the district began implementing a policy that would result in all students outside of the top 5% of the class taking Algebra in the eighth grade. Students in 7th grade during this school year were enrolled in Pre-Algebra in order to develop the skills necessary to succeed in Algebra 1. Beginning in the 2015-2016 school year, the lower track (Math 8) was eliminated, and all students were enrolled in either Algebra 1 (bottom 95%) or Geometry (top 5%) in eighth grade.

This study examines the effect of this policy shift on student achievement, measured through the Partnership for Assessment of Readiness for College and Career (PARCC) assessment. The policy's efficacy in improving Algebra achievement was measured by students' end-of-course Algebra PARCC assessment scores. The policy's effect on future math achievement was measured by students' performance on the Geometry PARCC Assessment after their completion of Algebra.

Delimitations

The study was restricted to an examination of two eighth-grade classes from Fort Lee Public Schools: those in eighth grade during the 2014-2015 school year (the treatment group) and those in eighth grade during the 2015-2016 school year. More specifically, the study concentrated on those who took Math 8 or Algebra during the 2014-2015 year or those who took Algebra during the 2015-2016 year. The group of students taking Geometry (top 5% of class) was not affected by the new policy. The study only included subjects who met the following criteria:

- Passed Algebra in Fort Lee Public Schools on their first attempt
- Sat for and received valid scores for the Algebra end-of-course PARCC assessment in Fort Lee Public Schools
- Took Geometry in Fort Lee Public Schools
- Sat for and received valid scores for the Geometry end-of-course PARCC assessment in Fort Lee Public Schools

Purpose

There are a number of demographic and organizational factors that contribute to student achievement in mathematics at the middle and high school levels. Several studies have identified a student's race as an exogenous factor that correlates with achievement in school (Harris & Herrington, 2006) and in particular mathematics (Phillips, Crouse, & Ralph, 1998). This correlation is borne out in black and Hispanic students' significantly lower achievement (when measured by the National Assessment of Educational Progress (NAEP) test) in mathematics compared to other races. Often linked to race, a student's socioeconomic status has also been linked to achievement (Diaz, 2008) with a medium to strong relationship between a student's low socioeconomic status and lower achievement (Sirin, 2005). Gender is another demographic variable that has been studied to identify elements that affect student achievement (Casad, Hale, & Wachs, 2015; Cheryan, 2012). The disparities in outcomes highlight the importance of identifying policy effects on those at risk of lower performance due to non-organizational variables. Finkelstein and Snipes (2014) demonstrated that introducing Algebra in the eighth grade results in a bimodal distribution of success and failure. They also acknowledge that failure can lead to long-term harm in terms of success in math, which may outweigh the increase in the number of students finishing Algebra one year earlier. This study builds on this body of research by examining how effective a universal eighth-grade Algebra policy was in accomplishing its goals of improving future success in mathematics while maintaining success in Algebra. The study looks at both the heterogeneous population of students who were affected and includes a targeted analysis of those groups of students that the research identifies as at risk of lower achievement based on demographic variables. The following research questions guide the study:

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by students' performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?
- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by performance on the Geometry PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the future achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Geometry PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and

Hispanic students' achievement, measured based their performance on the Geometry PARCC end-of-course assessment?

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?
- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students, measured by their performances on the Geometry PARCC end-of-course assessment?

Significance of the Study

The results of this study can contribute to the field of education research in a number of ways. This can inform policymakers' decisions regarding the sequencing of the K-12 math curriculum, particularly with regard to how these decisions can help demographic subgroups including black and Hispanic students, socioeconomically disadvantaged students, male students, and female students. Research on policies mandating Algebra 1 in the eighth grade is abundant, and this study seeks to add context based on how these policies have affected a medium-sized suburban school district in New Jersey.

Hypothesis

The hypothesis of this study is that middle schools that adopt policies mandating Algebra in the eighth grade see improvements in student achievement in Algebra as well as student achievements in future math courses, measured by the end-of-course standardized assessments offered in the respective courses. The null hypothesis states that schools that adopt such policies do not realize a significant improvement in student scores on end-of-course exams versus scores from students who were in eighth grade prior to the policy's adoption. School leaders and decision-makers could benefit from the rejection of the null hypothesis by indicating one controllable variable that may result in an increase in student achievement both in Algebra and future courses. Similarly, they can benefit from the retention of the null hypothesis by eliminating access to Algebra in the eighth grade as a contributing factor to achievement in Algebra and future courses.

Definition of Key Terms

Algebra 1 – Middle or high school level course that is aligned with the Common Core State Standards for Algebra 1

Geometry – High school course aligned with the Common Core State Standards for Geometry

Algebra 2 – High school course aligned with the Common Core State Standards for Algebra 2

Advanced Math – High school courses requiring Algebra 2 as a pre-requisite

Common Core State Standards – Set of interstate academic standards recognized as an acceptable framework for instruction of specific courses by adopting states

Partnership for Assessment of College and Career Readiness – Consortium responsible for the development of end-of-course exams testing students' mastery of the Common Core State Standards

Detracking – Eliminating or reducing courses designated for specific student abilities, resulting in increased heterogeneity in classes

Algebra in eighth grade – A policy that allows the whole eighth-grade student body in a school to take *at least* Algebra in eighth grade (Students still may take Geometry if they have demonstrated the aptitude to accelerate even more quickly through the mathematics curriculum.)

Economically disadvantaged – A status attributed to any student in the study who is enrolled in the free and reduced lunch program

Chapter II

REVIEW OF THE LITERATURE

Introduction

The tracking of students into different levels based on perceived ability has proven to be a controversial topic in education policy development. Some argue that it is exceedingly difficult to identify students' abilities effectively enough to assign them appropriately to narrow tracks, and that the more tracks there are, the more likely students are to be misplaced, either in a level that is overly high or overly low (Rubin, 2006). Others take the position that tracking allows for curricula to be tailored to meet a more diverse population and that the practice limits the number of students who are stuck in classes that are easy or hard according to their ability (2006). At the crossroads of this debate on tracking is the policy requiring algebra for all students in the eighth grade. This policy has seen waves of popularity in the last few decades as decision-makers grapple with the pros and cons of having heterogeneous groups of students take advanced level math courses for their ages (Snipes & Finkelstein, 2015).

Algebra in the Eighth Grade

At the core of Algebra in eighth grade policies is the understanding that moving students successfully through Algebra at a younger age (rather than a generic "eighth-grade math," or Pre-Algebra) can advance them through the foundational high school courses (Algebra, Geometry, and Algebra 2) one year quicker, allowing more access to pre-calculus and more advanced topics in the 11th and 12th grades, rather than just the 12th (Loveless, 2009). Whether or not schools are adopting universal eighth-grade Algebra policies or keeping tracked math but pushing students toward the Algebra track, Algebra has become the most common math course taken by eighth graders in America (p. 10). Contributing to this trend are the statewide Algebra in eighth grade policies that were adopted by California and Minnesota in 2011.

The Algebra in eighth grade policy in California has led to both positive and negative results (Williams, Haertel, & Kirst, 2011). Many of the students who would not have had access to Algebra in eighth grade prior to this policy based on tracking criteria are doing well. More specifically, 3.8 times as many economically disadvantaged eighth graders are achieving proficient or higher scores on the Algebra 1 state standardized test. This reveals an inefficiency in tracking policies that is effectively eliminated by universal Algebra in eighth grade policies, which provide access to Algebra courses for all students who can be successful. On the other hand, the number of students taking Algebra in eighth grade who are not prepared has also increased: “more than half of eighth graders who take the Algebra I CST score below proficient on the test. More economically disadvantaged eighth graders scored ‘Below Basic,’ or ‘Far Below Basic,’ in 2009 than took the Algebra I CST at all in 2003.” (p. vii)

With the increased emphasis on college and career readiness, universal Algebra policies in middle schools have become more popular in the United States (Nomi & Allensworth, 2014). While Algebra in eighth grade is a detracking policy, it is also a movement to accelerate the mathematics curriculum and offer more students access to higher level courses in high school and beyond. The logical result of offering Algebra in the eighth grade is that students finish their core math courses one year earlier and become eligible for higher level math electives for two years rather than one.

Finkelstein and Snipes (2015) researched how Algebra in eighth grade affects student achievement in future math courses. Their research demonstrates that future math achievement is linked to success in Algebra. Those students who experience success on the first attempt at Algebra experience a statistically significant increase in achievement in mathematics in future courses. Those who fail, however, have relatively low chances of ever becoming proficient in Algebra, and therefore have a low chance of succeeding in more advanced courses. The natural conclusion from Finkelstein and Snipes' research is that it is essential for students to be exposed to Algebra at an appropriate time, when they are equipped with the background and skills for success, in order to optimize achievement outcomes.

While premature placement in an Algebra 1 course, with regard to a student's mastery of the pre-requisite skills that allow for success, has had deleterious effects on a student's future performance in math, Gamoran and Hannigan (2000) studied the potential positive effects on students who take Algebra 1 in the eighth grade.

Tracking and Detracking

Tracking of students has been the common technique in public school course organization for the past five decades. However, research on the practice has revealed several downsides (Rubin, 2003). Research has demonstrated that tracking correlates with achievement, i.e., those students who are tracked into a lower level course subsequently experience lower achievement (Welner & Burris, 2006). However, this is to be expected based on the criteria according to which students are tracked.

Ability tracking has had a significant impact on how teachers approach and view their instruction of middle school mathematics (Worthy, 2010). Worthy interviewed 25 teachers about their experiences teaching both honors and "regular" classes. The study found that the teachers viewed and approached their classes and monolithic groups by assigning stereotypical, static characteristics to them “in the absence of evidence.” Worthy also identified major differences in the quality of instruction in the two tracks, finding that honors classes were more likely to experience more creative and sophisticated instruction as well as increased freedom to move about the class and engage in discussions without reprimand. The opposite was identified in the “regular” classes. One teacher who was interviewed stated, “we do a lot of seatwork and there’s not a lot of talking, not a lot of discussion” (Worthy, 2010).

Research has demonstrated that tracking has little effect on the mean student achievement, but the distribution of achievement is affected (Loveless, Thomas, & Fordham, 2009). Loveless found that while the average student population remained unaffected, the achievement gap between low-achieving and high-achieving students increased (the higher achieving students performed better and the lower achieving students performed worse in a tracked environment). This is a particularly important finding because tracking is often a proxy for socioeconomic status. Policy makers must consider this bimodal distribution when evaluating universal Algebra sequencing. Insofar as the goal is to improve access to and performance in advanced math courses, the achievement gains of the high-tracked students must be considered against the negative consequences for the low-tracked students.

Loveless et al. (2009) examined the effects of tracking on middle school students in Massachusetts. The schools studied tracked students by subject matter rather than more traditional tracking into cohorts for the entire curriculum. Loveless’ research demonstrates that students in tracked schools perform up to 3% better on test scores as they move up each track. Detracking results in high-aptitude students not being exposed to a more rigorous curriculum and therefore not undergoing the enriching experience that would result from this higher achievement.

Burris and Garrity (2008) came to the opposite conclusion, advocating for detracking as a means of granting students' access to the optimal curriculum for all. The researchers raised several concerns that have arisen in districts that are heavily tracked. Tracking often results in increased segregation, a point agreed upon by Loveless. Regardless of the tool used for the assignments of tracks, blacks, Hispanics, and students in lower socioeconomic strata are disproportionately represented in the lower tracks. Another externality examined by the researchers is the phenomenon that better teachers are assigned to higher tracks, furthering the equity gap between high and low tracks. Concerns about the tools used for track placement have also been raised. Although the decision on how to track differs by district, criteria often include measures such as motivation as perceived by previous teachers and scores on standardized tests. The unscientific application of these criteria can contribute to the real and perceived inequalities in access that arise from tracking policies.

Nomi and Allensworth (2014) quantifiably investigated the results of tracking specifically in Algebra classes. Their results demonstrated that students in the lower tracks benefited from being placed in higher level courses. Those students who had been tracked higher, however, did worse, which resulted in an overall shift to the middle. Nomi and Allensworth's research demonstrates that, insofar as student achievement is measured by test scores, there is a net increase in achievement in tracked schools due to higher achieving students realizing higher gains than the losses they experienced in de-tracked schools.

Advanced Math in High School

At the heart of policies accelerating the sequence of math courses by requiring Algebra in the eighth grade is the goal of increasing students' access to advanced math courses at the high school level. Many studies have demonstrated that participation in different levels of advanced math has positive effects on students' college acceptances, college success, and career success (Achieve, 2013). A study on high school students in the 1990s and 2000s revealed that students who took advanced math courses (Algebra II or higher) were 20% more likely to start college at a four-year school by the age of 21 (Aughinbaugh, 2012). Adelman found, in 2004, that not only are students who have taken advanced math more likely to attend college, but those who finish a course beyond Algebra 2 in high school are also more than doubly likely to enroll in college to complete a bachelor's degree. Students enrolled in advanced math as juniors and seniors in high school have higher earnings than those not enrolled seven years after the course was taken (Bozick & Ingels, 2008), and approximately 75% of adults making up the top 25% of earners took at least Algebra II in high school (Carnevale & Desrochers, 2003). As research has established, there are clear benefits to making advanced math curricula accessible to as many students as possible when developing policy on math course sequencing.

Another benefit of an Algebra in eighth grade policy is its effect on the accessibility gap that exists with regard to advanced math in high school. While the benefits of a rigorous math curriculum are clear, inequity with regard to access to advanced math courses exists on both the individual student and school levels. According to the National Center for Education Statistics (2012), approximately 71% of black and Hispanic graduates took Algebra II or higher, while 83% of Asian and 77% of white graduates took these courses. The Civil Rights Data Collection

(2012) found that not only are less students of color taking these courses, but they are also disproportionately enrolled in schools that do not even offer these courses (2012). This study found that less than a third of schools serving primarily minority students offer Calculus, while the average for all schools is 50% .

Improving racial and socioeconomic equity in access to advanced math in high school can also help achieve equity through college and after. Completion of an advanced math course in high school has been associated with a 36% to 59% increase in college completion rates in low-income students and a 45% to 69% increase in college completion rates for Latino students (Adelman, 2006). Future earnings are also positively affected by minority students' completion of these courses. A study by Goodman (2009) revealed that each additional math course completed by black students increased their annual earnings by 8% . According to Rose and Betts' (2004) study on the effect of high school courses on future earnings, inequities in access to advanced math course account for one-quarter of the income gap between low- and middle-income families when measured 10 years after high school graduation. By adopting Algebra in eighth grade policies, school districts can remove the accessibility gap at this grade level. As long as students progress through the math curriculum at the same rate, such policies should not only increase the number of students overall who are taking advanced math in high school but also eliminate the inter-district accessibility gap based on both socioeconomic and racial differences.

Exogenous Factors Related to Math Achievement

There exists a large body of literature examining the effects of a number of different variables on achievement in math. This section of the literature review identifies these variables in order to lay the foundation for the development of the statistical model that is used to answer this study's research questions. A number of factors that have been identified as having an effect on math achievement are excluded based on the context of this study. For example, smaller classes have a positive impact on math achievement (Hattie, 2005). However, this variable remained constant in all sample subjects and therefore could not be controlled for. Teacher effectiveness has been identified as another major, contributing factor to achievement (Borman & Dowling, 2008). However, again this variable remained constant across the sample. To this end, the confounding variables included in this study were limited to demographics and prior achievement.

Students' race has had a large, and significant effect on student achievement, as measured by the NAEP test since its inception in 1973 (Harris & Herrington, 2006). The differences in achievement between white and black and Hispanics students have remained constant over the last 20 years (Shelly, 2009). Notably, and specific to math achievement, the racial achievement gap becomes larger as students grow older and enroll in higher levels of mathematics (Phillips et al., 1998). Phillips et al.'s study identified a gap of up to .34 standard deviations when comparing black students' achievement against white students' achievement. Established research has clearly identified race as a significant variable in student achievement in all content, but specifically in mathematics.

Socioeconomic status is another factor that has been linked to academic achievement (Diaz, 2008). Diaz's study demonstrated that students' socioeconomic status played a significant role in predicting student achievement in both large and small school districts. A meta-analysis by Sirin (2005) also indicated a medium to strong negative positive relationship between a students' socioeconomic status and academic achievement. Sirin's study did indicate a slight decrease in correlation compared to the study he was replicating (White, 1982). However, the study maintained a significant relationship between socioeconomic status and achievement.

Student gender has also been found to have a statistically significant effect on math performance, with boys outperforming girls, in particular when achievement is measured by standardized test scores (Fryer & Levitt, 2010). Scores on the math portion of the SAT illustrate that female scores are .3 standard deviations lower than males on average (College Board, 2007). This gender gap in math achievement is of particular importance due to its direct contribution to differences in employment opportunities and the wage gap in the future (Paglin & Rufolo, 1990).

Students' intrinsic feelings toward mathematics, i.e., their self concept of their own math abilities and/or their anxiety with regard to math courses and tasks, have been identified as another significant factor affecting math achievement (Arens et al., 2017; Marsh, 2007). A clear, inverse relationship has been established in comparisons of levels of math anxiety with achievement in mathematics (Hembree, 1990). Interestingly, Hembree found that whole-class approaches and curriculum overhauls (such as the algebra in eighth grade policy being studied) do not reduce math anxiety in a significant way. However, higher anxiety levels do exist in remedial or lower track math classes. This finding is likely attributed to the fact that students with high math anxiety perform at lower levels and are therefore grouped into remedial classes, rather than any curricular reason.

Math anxiety and its subsequent effect on achievement has been linked to stereotypes regarding gender and math (Cheryan, 2012). Cheryan found that the performance gap has greatly decreased, if not disappeared, in recent years between girls and boys' math achievement. However, participation rates in advanced math courses and college majors continue to favor males. The internalization of gender stereotypes has had negative effects on math achievement for both girls and boys (Casad et al., 2015). Although the performance gap is no longer pronounced, math anxiety caused by gender stereotypes (boys feeling pressure to thrive in math and girls feeling as if they likely will not) results in decreased performance by both genders (Casad et al., 2015). The threat of stereotypes leading to increased anxiety (and therefore decreased performance) does not only affect students, but can also be reinforced by math-anxious female teachers (Beilock, Gunderson, Ramirez, & Levine, 2010). The adoption of a more rigorous Algebra curriculum in eighth grade for all students, regardless of gender, may help tackle decreased achievement due to increased math anxiety associated with gender stereotypes.

The variables of socioeconomic status, race, and gender cannot be modified through changes to school districts or policy. To this end, this study controls for these variables in its statistical analysis in order to isolate the Algebra eighth grade policy that is being examined.

Chapter III

METHODOLOGY

Dominant Research Method

This research project uses a quantitative, explanatory framework to address the effect of a policy that mandates that all eighth-grade, general education students in the Fort Lee Public Schools take Algebra 1 or a more advanced math course. The school district has one middle school that all eighth graders attend. Therefore, an explanatory study can be used to examine the effect of the policy and control for other factors (building, school climate, etc.). The only major policy and curricular shift affecting the students studied was the new Algebra eighth eighth grade placement policy.

Specific Design

Prior to the 2015-2016 school year, eighth-grade students in Fort Lee Public Schools were tracked into Pre-Algebra, Algebra I, and Geometry. Algebra I and Geometry were reserved for the approximate top 25% of students, determined based on students' final grades in seventh-grade math. When the policy was put into effect in 2015-2016, all eighth-grade students in general education math were enrolled in Algebra I or Geometry. The latter was reserved for the top 10% of the class, measured by performance in sixth-grade math (placement in Algebra 1 in the seventh grade is a pre-requisite for eighth-grade Geometry). For the purpose of this study, the students that were exposed to the policy being studied are referred to as being members of $T_{1,}$ while those who took the traditional course sequence prior to the policy are referred to as members of T_0.

The timing of the policy implementation coincided with the adoption of the Common Core State Standards in New Jersey and the subsequent administration of the PARCC assessment. This study examines the PARCC scores of students who were enrolled in Math 8 during the 2014-2015 school year (T_0) as compared to the cohort of eighth-grade students who took Algebra I during the 2015-2016 school year (T_1).

This study measures two effects with regard to the Algebra in eighth grade initiative: success in Algebra, measured by scores on the Algebra 1 PARCC Assessment, and success in future math courses, measured by scores on the Geometry PARCC Assessment. The study compares the eighth-grade class of 2015, the majority of whom enrolled in an Algebra preparation course, against the eighth-grade class of 2016, the majority of which enrolled in Algebra 1. The cohorts are highly comparable as the students attended the same schools and are only one year apart. The demographics in the town have remained largely the same. The only appreciable difference in the students' experiences, other than the independent variable, is the one-year difference in grade level.

The specific design of the study is an explanatory/causal comparative design. The study examines two cohorts of students that took Algebra 1 at different times in the same district and school. Students who were enrolled in Algebra as a result of the new policy experienced more or less the same conditions as those from prior years. This study looks at students who are only one year apart in the same school, which controls for all major factors other than the new Algebra policy.

Potential Population

The potential population for this study encompasses all eighth-grade, regular-education students in New Jersey in medium-sized districts. Schools in this population have to have taken the PARCC assessments for Algebra and Geometry. Students in districts that have adopted Algebra in the eighth grade as well as those that are considering this policy can gain insight from the results of this study.

Recruitment and Selection of Subjects

Subjects were selected and grouped into control (T_0) or treatment (T_1) groups based on the grade level during which they enrolled in Algebra 1. Those students who enrolled in Algebra 1 in the eighth grade as a result of the Algebra in eighth grade policy made up the control group. Those who enrolled in Algebra 1 in the ninth grade, after completing a traditional Math 7 – Math 8 middle school sequence made up the treatment group. In both groups, Algebra 1 was taken during the 15-16 school year. The study consists only of students who were enrolled in Algebra 1, not those enrolled in Algebra 1 Honors.

Based on initial enrollment in Math 7, the treatment group initially consisted of 157 subjects. Several subjects who would have otherwise been included in the study were ineligible because participation in the PARCC exams was used as both an independent and dependent variable in the study. There are a number of reasons why student data might not have been available for one or multiple of the PARCC tests included in the study, e.g., transfers, testing opt-outs, absences during testing dates, etc. Of the 157 subjects, 17 did not participate in the Math 7 PARCC exam, which is the achievement variable in this study. This disqualified them from being included in the study. Of the remaining 140 students, 10 did not take the Algebra 1

PARCC or Geometry PARCC exam, which necessarily excluded them from the study. This left 130 subjects included in analysis of at least one of the main research questions. With regard to the main research question addressing performance on the Algebra 1PARCC exam (and corresponding sub-questions), a total of 121 students had the necessary testing data (Math 7 scores and Algebra 1 scores) and were therefore included. With regard to the main research question addressing performance on the Geometry PARCC exam (and corresponding sub-questions), a total of 110 students had the necessary testing data (Math 7 and Geometry scores) and were therefore included.

The initial control group consisted of all students who were enrolled in Math 8 during the 14-15 school year. These students represented the final group, which followed a traditional Math 7 – Math 8 middle school curriculum sequence and were unaffected by the universal Algebra 1 in eighth grade policy. Initial enrollment in Math 8 during the 14-15 school year totaled 175 students. Of these students, 30 did not sit for the Math 8 PARCC exam, which was used as the independent variable representing prior math achievement, and therefore were excluded from the study. Of the remaining 145 students, 20 did not sit for either the Algebra 1 PARCC or Geometry PARCC exams in the district in subsequent years and therefore could not be included in an analysis of either research question. The remaining 125 students were included in the analysis of one or both of the main research questions. One hundred and twenty-four of the students sat for the Math 8 PARCC and Algebra 1 PARCC in the district and were therefore included in an analysis of the research question regarding performance in Algebra 1 and all corresponding sub-questions. One hundred and fourteen of the students sat for the Math 8

PARCC and the Geometry PARCC in the district and therefore were included in the analysis of the research question regarding performance in Geometry and all corresponding sub-questions.

Although the sample sizes for the total cohort analyses are adequate, some of the sub-question analyses on specific demographic groups do not meet certain thresholds for sample size minimums. In a hierarchical regression analysis, an adequate sample size can be defined as 104 + k, where k represents the number of variables included in the study (Field, 2013). At the sub-question level, five variables were included, which means a minimum sample size threshold of 109 should be met. There were five sub-questions that did not meet this threshold: the sub-questions dealing with the Algebra performance of economically disadvantaged students (n = 62), the Algebra performance of black and Hispanic students (n = 69), the Geometry performance of economically disadvantaged students (n = 60), the Geometry performance of black and Hispanic students (n = 62), and the Geometry performance of female students (n = 104). The sub-question on the Geometry performance of female students has a borderline sample size, which may be acceptable based on other standards, such as G-Power. However, the sample size is still slightly below the threshold established by Field's research (2013). While these sub-questions do not meet sample size minimums, the results may still offer insights and can contribute to research. Sample size issues do represent a limitation in this study and should be considered through this lens when interpreting the results of specific questions.

To illustrate the distribution of subjects, the tables below list the cohort numbers in both T_1 and T_0 for each of the two overarching research questions. The same samples are used to answer all sub-questions related to the following overarching question:

- **R1. How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by performance on the Algebra 1 PARCC end-of-course assessment?**

Table 1: Algebra 1 Sample Size

Cohort	**Total Potential Subjects**	**Subjects included in study**	**Subjects excluded due to missing prior achievement data (Math 7 scores for T_1 or Math 8 scores for T_0)**	**Subjects excluded due to missing Algebra 1 achievement data**
T_1 – Students who took Algebra 1 in the eighth grade as a function of policy adoption	157	**121**	17	19
T_0 – Students who took traditional Math 7 – Math 8 middle school sequence prior to policy adoption	175	**124**	31	20

- **R2. How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by performance on the Geometry PARCC end-of-course assessment?**

Table 2: Geometry Sample Size

Cohort	Total Potential Subjects	Subjects included in study	Subjects excluded due to missing prior achievement data (Math 7 scores for T_1 or Math 8 scores for T_0)	Subjects excluded due to missing Geometry achievement data
T_1 – Students who took Algebra 1 in the eighth grade as a function of policy adoption	157	**110**	17	30
T_0 – Students who took traditional Math 7 – Math 8 middle school sequence prior to policy adoption	175	**115**	31	29

Instruments and Data Collection

Data for the study was collected primarily from two sources. The school district's student management system, Genesis, provided all demographic data, including information on course enrollments, free and reduced lunch eligibility, transfer status, and other details. Scores on the PARCC assessments were accessed through the assessments online data publishing system, Pearson Access Next. This data includes students' scores on the Geometry PARCC Assessment as well as the Algebra 1 PARCC Assessment.

Data Validity and Reliability

Measures were taken to ensure the validity and the reliability of the study's results. The PARCC assessment has been widely studied and demonstrated as both valid and reliable in measuring students' mastery of the Common Core State Standards.

The study used multiple comparative means tests, including chi-squared and t-tests, to ensure internal validity.

Protection of Subjects

Since this study analyzes codified private information, based on which investigators cannot readily ascertain the identity of any individual, the study does not meet the National Institute of Health's threshold for human subject research. The sample sizes of both the control and treatment group are adequate to protect subjects' privacy and anonymity.

Status of Variables

The independent variables in this study include nominal/categorical groupings. These variables include students' enrollment in eighth-grade Algebra 1 in the 2015-2016 school year and those enrolled in Algebra 1 or Math 8 in the 2014-2015 school year. The second independent variable included in the study is students' socioeconomic status, indicated by enrollment in the free and reduced lunch program.

The dependent variables in this study are scale ratio numbers. These variables include students' scores on the Algebra I PARCC assessment at the conclusion of the 2014-2015 school year or 2015-2016 school year depending on their enrollment status. Scores on the Geometry PARCC Assessment at the conclusion of the 2015-2016 school year or 2016-2017 school year were also included depending on students' enrollment status.

Analytical Model

A review of the literature has indicated a number of exogenous variables that contribute to student achievement in mathematics outside that of the independent variable in the study (exposure to Algebra in the eighth grade for all students). The model used to analyze the policy's effect on achievement, therefore, includes demographic data including race, socioeconomic status, and gender. Prior achievement was also controlled for when appropriate in order to address specific research questions.

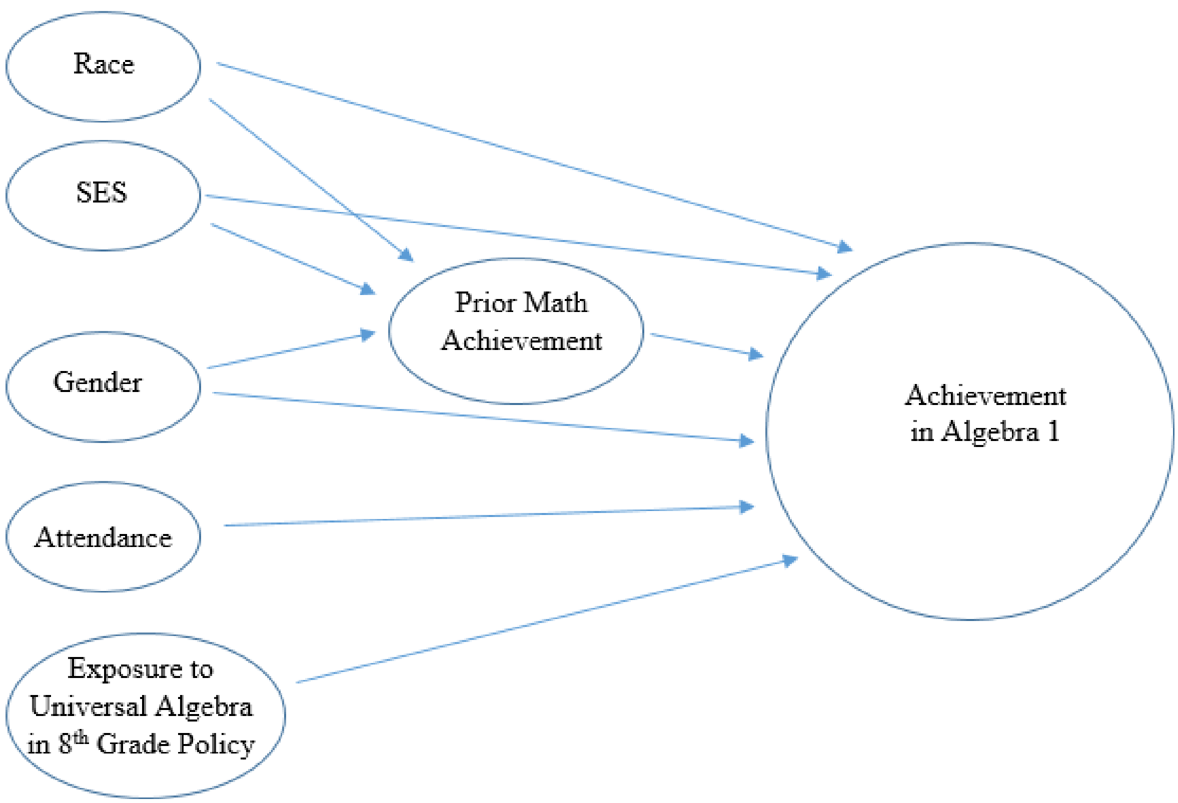

Figure 1: Potential Contributors to Algebra Success (Created by Crawley, 2018)

Figure 1 graphically depicts the paths through which this demographic data affects both prior math achievement and the outcome variable of achievement in Algebra 1. Race (Harris & Herrington, 2006), socioeconomic status (Diaz, 2008), and gender (Fryer & Levitt, 2010) have had significant effects on math achievement throughout all grade levels. These variables can be expected to have an impact on students' achievement in Algebra 1, both directly and indirectly, based on prior achievement. Prior achievement represents the binary variable that determines whether or not a student was enrolled in Math 8 or Algebra 1 in the eighth grade (prior to the adoption of the policy) or whether they would have been enrolled in Math 8 or Algebra 1 based on Grade 7 PARCC scores (after the adoption of the policy). This initial model was used to address the first research question:

> How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by performance on the Algebra 1 PARCC end-of-course assessment?"

The model was modified to answer subsequent research questions as detailed below.

> In order to answer the first sub-research question
>
> (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, as measured by performance on the Algebra 1 PARCC end-of-course assessment?),

it was not necessary to control for socioeconomic status. The sample being analyzed consisted only of those students identified as low socioeconomic status students, eliminating any effect in variability that this status would have on the results. Figure 2 demonstrates how the model was adjusted in order to address this research question.

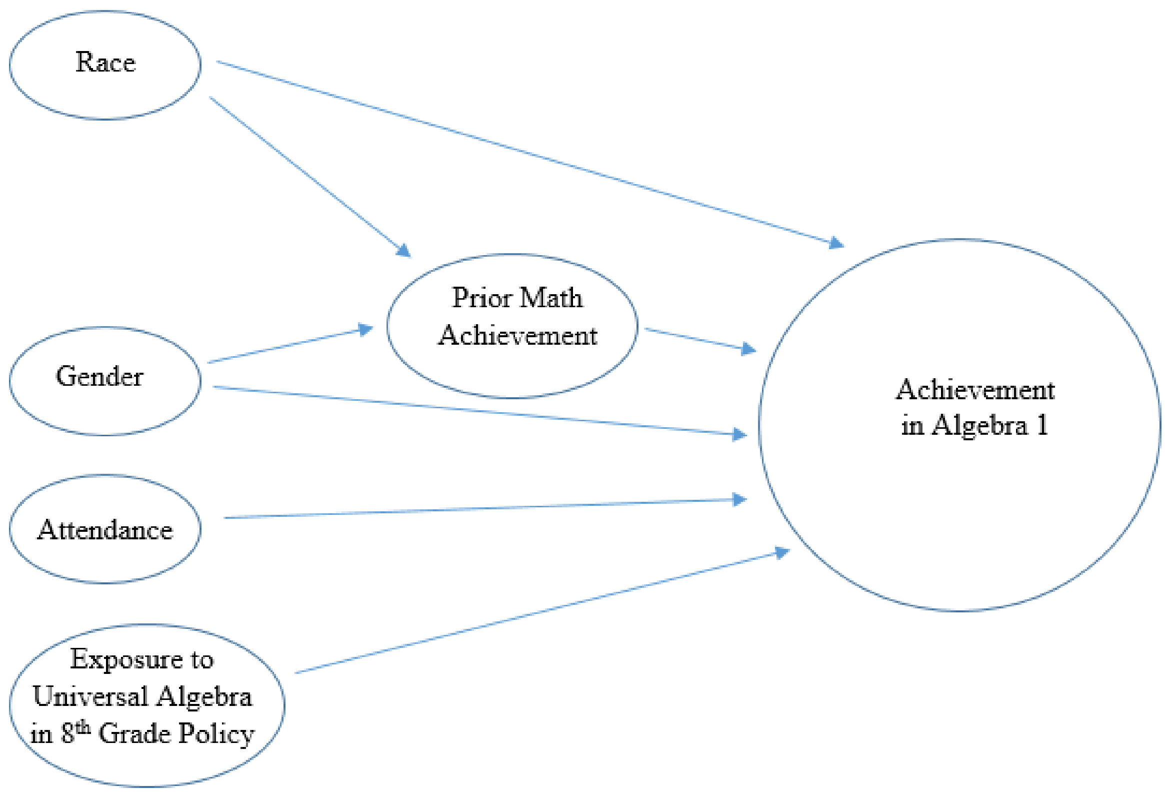

Figure 2: Contributors to Algebra Success (Economically Disadvantaged Students) (Created by Crawley, 2018)

The second sub-question analyzes only black and Hispanic students. Therefore, the race variable was excluded from the model.

The final two sub-questions for the first research question address the achievement of males and females separately based on their exposure to the policy. In each question, one gender was excluded, and the gender in question underwent the same statistical analysis to identify any unique effects on these subgroups. The model maintained all of the original variables, with the exception of gender.

The second research question and sub-questions deal with student performance in future math, measured by their performance on the Geometry PARCC. These models mimicked those used for the first research questions, with only the outcome variable changed to performance in advanced math rather than Algebra 1. The prior math achievement variable was still be measured by measured performance entering Algebra 1 and did not incorporate performance in Algebra 1. This method of analysis attempts to identify the longitudinal effect of this one-time tracking.

Analysis

The analysis of the data included targeted hierarchical regression analyses that addressed each research question. The models in the hierarchical regression include five independent variables: attendance, gender, socioeconomic status, race, and cohort, determined based on whether or not the student was subject to the Algebra in eighth-grade policy. The dependent variable differed depending on the research question being addressed. However, it was always one of the end-of-year PARCC exams. In each analysis, four models were tested: one using all five variables, one using the cohort and gender variables, one using the cohort and socioeconomic variables, and one using only the cohort variable. An analysis of variance (ANOVA) was conducted to determine the significance of each model. The following section identifies the specific samples and PARCC scores that were used in the analysis. In this discussion of the data analysis, Cohort A refers to those students who took either Algebra or Math 8 prior to the adoption of the Algebra in eighth grade policy (2015-2016 school year and earlier), and Cohort B refers to those students who took Algebra in eighth grade as per the universal policy (2016-2017 school year and later). Additionally, the term “all students” refers to only those who were affected by the policy (approximately the middle 80% of students). Those students who took Geometry in the eighth grade and students who took remedial Pre-Algebra in the eighth grade were not included in any of the analyses.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by performance on the Algebra 1 PARCC end-of-course assessment?

This research question was analyzed using data from all students in Cohorts A and B. The hierarchical regression used Cohort A's performance on the Algebra 1 PARCC Assessment when they took it, i.e., approximately half of the cohort's scores come from the eighth grade and half from ninth grade. The analysis included Cohort B's Algebra 1 PARCC Assessment scores, all of which were taken in students' eighth-grade year. In both cases, data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

  - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by performance on the Algebra 1 PARCC end-of-course assessment?

This research question was analyzed using data from students in Cohorts A and B who were enrolled in the free and reduced price lunch program at the time of analysis of the assessment. The hierarchical regression used Cohort A's performance on the Algebra 1 PARCC Assessment when they took it, i.e., approximately half of the cohort's scores came from the eighth grade and half from ninth grade. The analysis included Cohort B's Algebra 1 PARCC Assessment scores, all of which were taken in their eighth-grade year. In both cases, the data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of the group of students who would have otherwise been tracked into the lower, Math 8 course, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

This research question was analyzed using data from students who were enrolled in Math 8 or would have been enrolled in Math 8 rather than Algebra had the policy not been adopted in Cohorts A and B, respectively. The group of Cohort B "Math 8" students was estimated based on the group of students falling within the 10^{th} through 50^{th} percentile on the Grade 7 PARCC assessment. Group A students are those who were actually enrolled in Math 8 prior to the adoption of the policy. The hierarchical regression used Cohort A's performance on the Algebra 1 PARCC Assessment when they took it in the ninth grade. The analysis included Cohort B's Algebra 1 PARCC Assessment scores, all of which were taken in their eighth-grade year. In both cases, the data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of the group of high-achieving students who would have otherwise taken the course in a homogenous (rather than heterogeneous) group, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

This research question was analyzed using data from students who were enrolled in the Homogeneous Algebra track prior to policy implementation or would have been enrolled in the Homogeneous Algebra track had the policy not been adopted in Cohorts A and B, respectively. The group of Cohort B "Homogeneous Algebra" students were estimated based on the group of students falling within the 50th through 90th percentile on the Grade 7 PARCC assessment. Group A students are those who were actually enrolled in "Homogeneous Algebra" prior to the adoption of the policy. The hierarchical regression used Cohort A's performance on the Algebra 1 PARCC Assessment when they took it in the ninth grade. The analysis included Cohort B's Algebra 1 PARCC Assessment scores, all of which were from their eighth-grade year. In both cases, the data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect students' future achievement, measured by their performance on the Geometry PARCC end-of-course assessment?

This research question was analyzed using data from all students in Cohorts A and B. The hierarchical regression used Cohort A's performance on the Geometry PARCC Assessment when they took it, i.e., approximately half of the cohort's scores came from ninth grade and half from 10th grade. The analysis included Cohort B's Geometry PARCC Assessment scores, all of which were from students' ninth-grade year. In both cases, the data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the future achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Geometry PARCC end-of-course assessment?

This research question was analyzed using data from students in Cohorts A and B who were enrolled in the free and reduced price lunch program at the time of the analysis of the assessment. The hierarchical regression used Cohort A's performance on the Geometry PARCC Assessment when they took it, i.e., approximately half of the cohort's scores came from ninth grade and half from 10th grade. The analysis included Cohort B's Geometry PARCC Assessment scores, all of which were from students' ninth-grade year. In both cases, data only included students' first attempts on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of the group of students who would have otherwise been tracked into the lower, Math 8 course, in advanced math courses, measured by their performance on the Geometry PARCC end-of-course assessment?

This research question was analyzed using data from students who were enrolled in Math 8 or would have been enrolled in Math 8 rather than Algebra had the policy not been adopted in Cohorts A and B, respectively. The group of Cohort B "Math 8" students was estimated based on the group of students falling within the 10th through 50th percentile on their Grade 7 PARCC assessment. Group A students are those who were actually enrolled in Math 8 prior to the policy's adoption. The hierarchical regression used Cohort A's performance on the Geometry PARCC Assessment when they took it in the 10th grade. The analysis included Cohort B's Geometry PARCC Assessment scores, all of which were from the students' ninth-grade year. In both cases, data only included students' first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of the group of students who would have otherwise taken the course in a homogenous (rather than heterogeneous) group in advanced math courses, measured by their performance on the Geometry PARCC end-of-course assessment?

This research question was analyzed using data from students who were enrolled in the Homogeneous Algebra track prior to policy implementation or would have been enrolled in the Homogeneous Algebra track had the policy not been adopted in Cohorts A and B, respectively. The group of Cohort B "Homogeneous Algebra" students was estimated based on the group of students falling within the 50th through 90th percentile on their Grade 7 PARCC assessment.

Group A students are those who were actually enrolled in “Homogeneous Algebra” prior to the policy’s adoption. The hierarchical regression used Cohort A’s performance on the Geometry PARCC Assessment when they took it in the 10^{th} grade. The analysis included Cohort B’s Geometry PARCC Assessment scores, all of which were from the students’ ninth-grade year. In both cases, data included students’ first attempt on the assessment. For any student who took the assessment more than once due to course failure, subsequent attempts were excluded from the data set.

Chapter IV

ANALYSIS OF THE DATA

Introduction

The purpose of this study was to identify the effect, if any, that requiring students to take Algebra 1 in the eighth grade (as opposed to the ninth grade) has on their performance in both Algebra 1 and future math courses, measured by performance in Geometry. If student performance in Algebra or Geometry declined after the policy was implemented, the efficacy of the policy to improve student outcomes would be called into question.

Research Questions

This study was guided by two main research questions, each with four symmetrical sub-questions.

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and

Hispanic students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by their performance on the Geometry PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the future achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Geometry PARCC end-of-course assessment?
    - How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?

- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?
- How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?

Reporting of Results

Each research question underwent an identical statistical analysis, and the results were reported accordingly. The reporting of each question begins with a discussion of the descriptive statistics for the relevant subgroups, including mean, median, mode, standard deviation, range, maxima, minima, and sample size. An independent sample t-test was run to compare the groups in the two cohorts in order to identify any preliminary differences in their performance on the assessment being analyzed. Following this description, a hierarchical regression analysis and report is included, beginning with a description of the variables in each model. A discussion of the model summary follows in order to identify the significance, if any, in the F-change between models as well as the strength of the model in predicting outcomes, measured by R-square. The results of an ANOVA test on each model are discussed in order to identify the significance of each. Finally, there follows a discussion of each of the variables included in each model, which consists of the identification of each variable's B-value, significance, and the variance inflation factors (VIF) in order to identify any issues with collinearity. The reporting in this chapter consists exclusively of the results of the statistical tests that have been run. The implications of the results of each of these analyses on policy, practice, and research are included in the following chapter.

Summary of Findings

The dependent variables in this study are students' scaled score performance on the 2016 Algebra 1 PARCC assessment (for research question 1 and related sub-questions) and scaled score performance on the 2017 Geometry PARCC Assessment (for research question 2 and related sub-questions). The following section provides detailed information on each of the dependent variables:

- 2016 Algebra 1 PARCC
  - The scale scores for this test represent the outcome variable for the first research question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?) and all corresponding sub-questions
  - Students in both the treatment group (T_1 – eighth--grade students enrolled in Algebra 1) and control group (T_0 – ninth-grade students enrolled in Algebra 1) sat for the Spring 2016 administration of the Algebra 1 PARCC exam
  - Students' scale scores are reported on a scale from 650-850 and grouped into five levels of achievement:
    - "Did Not Yet Meet Expectations" – 650 through 699
    - "Partially Met Expectations" – 700 through 724
    - "Approached Expectations" – 725 through 749

        - "Met Expectations" – 750 through 804
        - "Exceeded Expectations" – 805 through 850
- 2017 Geometry PARCC
    - The scale scores for this test represent the outcome variable for the second research question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by performance on the Geometry PARCC end-of-course assessment?) and all corresponding sub-questions.
    - Students in both the treatment group (T_1 – eighth-grade students enrolled in Algebra 1) and control group (T_0 – ninth-grade students enrolled in Algebra 1) sat for the Spring 2017 administration of the Geometry PARCC exam.
    - Student scale scores are reported on a scale from 650-850 and grouped into five levels of achievement:
        - "Did Not Yet Meet Expectations" – 650 through 699
        - "Partially Met Expectations" – 700 through 724
        - "Approached Expectations" – 725 through 749
        - "Met Expectations" – 750 through 782
        - "Exceeded Expectations" – 783 through 850.

The study includes five independent variables, including three demographic variables that were identified in previous literature as having an impact on student math achievement as well as prior math achievement and enrollment status in the Algebra in eighth grade initiative. The following section describes each independent variable in detail:

- Race
  - Binary variable identifying students as either black/Hispanic or other.
  - Dummy coded as 1 = black/Hispanic and 0 = other.
- Gender
  - Binary variable identifying students as either male or female.
  - Gender is reported based on students' status in the district's student information system. This information is based on student and family self-reporting of the gender identification of students.
  - Dummy coded as 1 = female and 0 = male.
- Socioeconomic status
  - Binary variable identifying students as economically disadvantaged or not.
  - Status is based on student enrollment in the free or reduced lunch program, where enrollment in the program indicates economically disadvantaged status.
  - Dummy coded as 1 = economically disadvantaged and 0 = not economically disadvantaged.
- Prior achievement
  - Prior achievement is represented by each student's scale score on the most recent PARCC assessment in math. For students in T_0, this was measured by their performance on the Math 8 PARCC assessment from 2015. For students in T_1, this was measured by their performance on the Math 7 PARCC assessment from 2015.
  - Student scale scores for the 2015 Math 8 PARCC were reported on a scale from 650-850 and grouped into five levels of achievement:

        - "Did Not Yet Meet Expectations" – 650 through 69
        - "Partially Met Expectations" – 700 through 724
        - "Approached Expectations" – 725 through 749
        - "Met Expectations" – 750 through 800
        - "Exceeded Expectations" – 801 through 850.
    - Student scale scores for the 2015 Math 7 PARCC were reported on a scale from 650-850 and grouped into five levels of achievement:
        - "Did Not Yet Meet Expectations" – 650 through 699
        - "Partially Met Expectations" – 700 through 724
        - "Approached Expectations" – 725 through 749
        - "Met Expectations" – 750 through 785
        - "Exceeded Expectations" – 786 through 850.

Table 3: Full Names and Shortened Labels of all Variables

Variable	**SPSS Label**
Subject's status as part of the cohort affected by the Algebra in eighth grade policy. 0 = T_0 (not affected by policy, enrolled in Math 8 in eighth grade) 1 = T_1 (affected by policy, enrolled in Algebra 1 in eighth grade)	TreatmentstatusDummy
Subject's self-identified gender as per district registration records 1 = Female 0 = Male	SexDummy

Subject's self-identified race as per district registration records 1 = black or Hispanic 0 = Any other race	BlackHispanicDummy
Subject's status as economically disadvantaged as per enrollment in the free or reduced lunch program 1 = Economically disadvantaged (enrolled in free or reduced lunch) 0 = Not economically disadvantaged (not enrolled in free or reduced lunch)	EconDisadvantagedDummy
Scale score on 2015 PARCC exam (Math 7 for T_1, Math 8 for T_0)	PriorAchievement
Scale score on the 2016 Algebra PARCC exam	AlgebraAchievement
Scale score on the 2017 Geometry PARCC exam	GeometryAchievement

For the development of a clear picture regarding the makeup and demographics of the two cohorts included in the study, the following tables highlight the breakdown of each cohort in terms of the other variables included in the study:

Table 4: Racial Breakdown of Cohorts

	Black or Hispanic	**Not Black or Hispanic**
T_0 (Algebra in Grade 9)	47 (38%)	77 (62%)
T_1 (Algebra in Grade 8)	22 (18%)	99 (82%)

Table 5: Socioeconomic Status Breakdown of Cohorts

	Economically Disadvantaged	**Not Economically Disadvantaged**
T_0 (Algebra in Grade 9)	38 (31%)	86 (69%)
T_1 (Algebra in Grade 8)	24 (20%)	97 (80%)

Table 6: Gender Breakdown of Cohorts

	Male	**Female**
T_0 (Algebra in Grade 9)	62 (50%)	62 (50%)
T_1 (Algebra in Grade 8)	67 (55%)	54 (45%)

Table 7: Prior Achievement Breakdown by Cohort

	Mean	**Standard Deviation**
T_0 (Algebra in Grade 9)	748.39	30.857
T_1 (Algebra in Grade 8)	761.24	33.692

Table 8: Attendance by Cohort

	Mean	**Standard Deviation**
T_0 (Algebra in Grade 9)	11.1	11.031
T_1 (Algebra in Grade 8)	14.63	15.84

Procedure

In order to identify the significance, if any, of the impact that the adoption of the Algebra in eighth grade policy had on student performance, data had be to be gathered from the Fort Lee Public Schools. A request was made to the District Coordinator of Technology for the provision of a spreadsheet including all performance and pertinent demographic data from the 2015, 2016, and 2017 PARCC assessments. Performance and demographic data are available to district administrators through the online platform Pearson Access Next. Student performance data was cross-checked against student enrollment data that was pulled from the district's student information system, Genesis. The resulting Excel spreadsheet included the demographic data and PARCC performance data for every student who was enrolled in Algebra 1 in the district in 2016 (in both eighth and ninth grade) as well as every student who was enrolled in Geometry in the district in 2017 (in both ninth and tenth grade). The data was then filtered to exclude those students who did not have the achievement data (prior Algebra 1 or Geometry) according to the associated research questions. These students were removed from the data set. The data set was then scrubbed of any identifying labels, such as student ID numbers, names, addresses, and other elements, and provided to the researcher in Excel format. The data was then uploaded to the Statistical Package for Social Sciences (SPSS) for statistical analysis.

2016 Algebra 1 PARCC Assessment

The first phase of analysis is designed to identify the effect, if any, of the Algebra 1 for all students in the eighth grade policy on students' performance in Algebra 1. This analysis was done on five levels to address each research question. The first level included all students enrolled in Algebra 1 in the T_0 and T_1 cohorts who had recorded valid scores on both their previous math course PARCC exam and the 2016 Algebra 1 PARCC exam. The other four levels included only those students who satisfied the condition that was being addressed by the research question: all black or Hispanic students, all economically disadvantaged students, all males, and all females.

Full Cohort Analyses

In order to answer the first, main research question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by performance on the Algebra 1 PARCC end-of-course assessment?) An analysis was run on all eligible members of cohort $T_{0,}$ the students who were not affected by the policy and took Algebra 1 in the ninth grade, and T_1, the students who were affected by the policy and took Algebra 1 in the eighth grade. Descriptive statistics were measured for both T_0 and T_1 in order to create a profile of each cohort.

Table 9: Descriptive Statistics T_1 (Algebra)

T1 Statistics

AlgebraAchievement

N	Valid	121
	Missing	0
Mean		757.92
Median		760.00
Mode		731[a]
Std. Deviation		37.984
Variance		1442.810
Range		188
Minimum		662
Maximum		850

a. Multiple modes exist. The smallest value is shown

There were 121 students in the T_1 cohort who met the requirements to be included in the study. The mean score on the 2016 Algebra PARCC exam for these students was 757.92, with a standard deviation of 37.984. The median score for this cohort was 760. The scores ranged across 188 points, with the lowest being 662 (one student) and the highest being a perfect 850 (one student).

Table 10: Descriptive Statistics T_0 (Algebra)

T0 Statistics

AlgebraAchievement

N	Valid	124
	Missing	0
Mean		767.81
Median		767.00
Mode		768
Std. Deviation		29.799
Variance		887.973
Range		168
Minimum		682
Maximum		850

There were 124 students in the T_0 cohort who met the requirements to be included in the study. The mean score on the 2016 Algebra PARCC exam for these students was 767.81, with a standard deviation of 29.799. The median score for this cohort was 767. The scores ranged across 168 points, with the lowest being 682 (one student) and the highest being a perfect 850 (one student).

Table 11: Full Cohort Group Statistics (Algebra)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
AlgebraAchievement	1	121	757.92	37.984	3.453
	0	124	767.81	29.799	2.676

Table 12: Full Cohort Independent Sample T-Test (Algebra)

A preliminary comparative means test was run on the two cohorts to identify if a difference in achievement existed. An independent sample t-test was conducted to compare the achievement of those students taking Algebra 1 in the eighth grade (T_1) against those taking it in

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AlgebraAchievement	Equal variances assumed	6.730	.010	-2.272	243	.024	-9.897	4.356	-18.477	-1.317
	Equal variances not assumed			-2.265	227.399	.024	-9.897	4.369	-18.505	-1.289

the ninth grade (T_0). The results of the independent sample t-test indicate that there is a statistically significant difference in performance on the Algebra 1 PARCC exam between the two cohorts ($t_{(243)} = -2.272$, $p = .024$, two-tailed). Those students who were unaffected by the policy and therefore took Algebra 1 in the ninth grade (M = 767.81, SD = 29.799, N = 124) scored better on the Algebra 1 PARCC exam than those students who took Algebra 1 in the eighth grade as a result of the policy (M = 757.92, SD = 37.984, N = 121). The recorded mean difference of -9.897 showed that, on average, students who were not affected by the policy and took Algebra 1 in the ninth grade scored about 10 points higher on the PARCC exam than their Algebra 1 in eighth grade counterparts with a 95% confidence interval of the difference placing this difference in performance between 1.317 points and 18.477 points.

After an initial, independent sample t-test indicated a difference in students' average performance on the Algebra 1 PARCC, a hierarchical regression analysis was performed to determine the effect of the policy on students when the exogenous variables that have been identified as having an effect on math performance were controlled for. These variables included attendance, race, socioeconomic status, gender, and prior math achievement. The initial model that was run included all six variables in the study. Subsequent models then removed those variables identified as not having a significant impact on student achievement until an efficient model that was both significant and included only variables that were significant was left. Variables were removed individually in order of significance, and the variable with the largest p-value above .05 was removed in each subsequent model.

Table 13: Full Cohort Variables (Algebra)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement, BlackHispanicDummy[b]	.	Enter
2	.[b]	SexDummy[c]	Remove
3	.[b]	BlackHispanicDummy[c]	Remove
4	.[b]	EconDisadDummy[c]	Remove

a. Dependent Variable: AlgebraAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, four models were estimated. Model 1 included all six of the potentially significant predictive variables on Algebra 1 performance in the study: race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), sex (dummy coded: 1 = female, 0 = male), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 =

member of T_1 cohort that was affected by the "algebra for all" policy, 0 = member of T_0 cohort that was not affected by the "algebra for all" policy), attendance, and prior math achievement. In Model 2, the sex variable was removed, leaving four variables as predictors of Algebra 1 performance. In Model 3, the race variable was removed, leaving treatment status, economically disadvantaged status, attendance, and prior achievement as the four predictive variables of Algebra 1 achievement. Finally, in Model 4, the economically disadvantaged variable was removed from the variables included in Model 3, leaving only attendance, prior achievement, and treatment status as the three predictive variables for Algebra 1 achievement. The dependent variable in all models was achievement in Algebra 1,measured by student performance on the 15-16 Algebra 1 PARCC Assessment. The sample consisted of 245 students.

Table 14: Full Cohort Model Summary (Algebra)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.410[a]	.168	.147	31.752	.168	8.004	6	238	.000
2	.408[b]	.166	.149	31.718	-.002	.488	1	238	.486
3	.404[c]	.163	.149	31.706	-.003	.829	1	239	.364
4	.396[d]	.157	.146	31.767	-.007	1.918	1	240	.167

a. Predictors: (Constant), Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement, BlackHispanicDummy

b. Predictors: (Constant), Attendance, EconDisadDummy, TreatmentStatus, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, EconDisadDummy, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

Model 1, which used all six independent variables. was a statistically significant predictive model of the dependent variable performance on the Algebra 1 PARCC Assessment $F\text{-change}_{(6,238)}=8.004$, $p < .001$. An R^2 value of .168 indicates that 16.8%of the variance in performance on the Algebra 1 PARCC exam can be explained by the six independent variables that were included. Model 2 retained all of the predictive variables included in Model 1 with the exception of the sex variable. As would be expected with the removal of any one variable, the R^2 did decrease from .168 to .166. However, this change was found to not be statistically significant. The F-change $_{(1,238)}$ = .488, p = .486 indicates that the removal of sex did not result in a statistically significant change in the models predictive power. An R^2 value of .166 indicates that 16.6% of the variance in performance on the Algebra 1 PARCC exam can be explained by the five independent variables included in this model. Model 3 removed the race variable from the Model 2 variables as predictors of student performance on the Algebra 1 PARCC exam. Again, dropping a variable resulted in a decrease in the R^2 value. However, this change was found to not to be statistically significant. The F-change $_{(1,239)}$ = .829, p = .364 indicates that the removal of student gender did not result in a statistically significant decrease in the model's ability to predict Algebra 1 PARCC outcomes. An R^2 value of .163 indicates that 16.3% of the variance in performance on the Algebra 1 PARCC can be explained by the four predictor variables that were included. Finally, a fourth model was run and dropped the final non-significant variable identified in model development: economically disadvantaged status. Model 4 included only attendance, treatment status, and prior achievement as predictors of student performance on the Algebra 1 PARCC exam. This model had an R^2 value that was .006 less than Model 3. However, that reduction was not found to be statistically significant, with F-change $_{(1,240)}$ = 1.918, p = .167. The resultant R^2 of .157 indicates that 15.7% of the variance in Algebra 1 PARCC performance can be explained by attendance, prior achievement, and treatment status. Based on this analysis, Model 4 is the best predictor of Algebra 1 PARCC performance.

Although it has a smaller R^2 than the other models, the difference was not found to be statistically significant and only significant independent variables were included.

An ANOVA analysis indicated that all four models were statistically significant as predictors of Algebra 1 PARCC performance. Model 1 is statistically significant, $F_{(6,238)} = 8.004$, $p < .001$. Model 2 is statistically significant, $F_{(5,239)} = 9.527$, $p < .001$. Model 3 is statistically significant, $F_{(4,240)} = 11.71$, $p < .001$. Model 4 is statistically significant, $F_{(3,241)} = 14.917$, $p < .001$. Model 4 is the only model that did not include any non-significant predictor variables.

Table 15: Full Cohort Coefficients (Algebra)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	602.027	49.665		12.122	.000		
	TreatmentStatus	-8.572	4.267	-.125	-2.009	.046	.904	1.106
	BlackHispanicDummy	4.119	4.890	.054	.842	.401	.851	1.176
	SexDummy	2.858	4.092	.042	.699	.486	.986	1.014
	EconDisadDummy	5.719	4.876	.072	1.173	.242	.916	1.092
	PriorAchievement	.226	.065	.216	3.471	.001	.900	1.111
	Attendance	-.750	.151	-.299	-4.963	.000	.962	1.039
2	(Constant)	604.366	49.499		12.210	.000		
	TreatmentStatus	-8.647	4.261	-.126	-2.029	.044	.905	1.105
	BlackHispanicDummy	4.428	4.865	.058	.910	.364	.858	1.166
	EconDisadDummy	5.583	4.866	.071	1.147	.252	.917	1.090
	PriorAchievement	.225	.065	.215	3.457	.001	.901	1.110
	Attendance	-.755	.151	-.301	-5.003	.000	.964	1.037
3	(Constant)	613.631	48.424		12.672	.000		
	TreatmentStatus	-9.317	4.195	-.136	-2.221	.027	.933	1.072
	EconDisadDummy	6.569	4.743	.083	1.385	.167	.965	1.036
	PriorAchievement	.214	.064	.205	3.349	.001	.932	1.074
	Attendance	-.743	.150	-.296	-4.946	.000	.971	1.030
4	(Constant)	625.005	47.813		13.072	.000		
	TreatmentStatus	-9.847	4.186	-.143	-2.352	.019	.940	1.063

PriorAchievement	.202	.063	.193	3.180	.002	.950	1.052
Attendance	-.749	.151	-.299	-4.978	.000	.972	1.029

a. Dependent Variable: AlgebraAchievement

In Model 1, none of the demographic variables were statistically significant: economically disadvantaged status ($p = .242$), sex ($p = .486$), and race ($p = .401$). Prior achievement ($B = .216$, $t = 3.471$, $p = .001$), treatment status ($B = -.125$, $t = -2.009$, $p = .046$), and attendance ($B = -.299$, $t = -4.963$, $p < .001$) were statistically significant predictors of Algebra 1 PARCC performance. The positive value of B associated with the prior achievement variable indicates that a higher score on the prior achievement assessment is associated with a higher score on the Algebra 1 PARCC exam. The negative value for B associated with treatment status indicates that those students who were subject to the Algebra in eighth grade policy performed worse than those who were not subject to the policy on the Algebra 1 PARCC exam. The negative value for B associated with attendance indicates that students who were absent more often performed worse on the Algebra 1 PARCC exam than those who missed less school. There are no concerns regarding collinearity or multicollinearity, as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.106$, $VIF_{BlackHispanicDummy} = 1.176$, $VIF_{SexDummy} = 1.014$, $VIF_{EconDisadDummy} = 1.092$, $VIF_{PriorAchievement} = 1.111$, and $VIF_{Attendance} = 1.039$.

In Model 2, sex was excluded as an independent variable based on the non-significant p-value observed in Model 1. The remaining demographic variables in the resultant model continued to be non-significant predictors of performance on the Algebra 1 PARCC exam: race ($p = .364$) and economically disadvantaged status ($p = .252$). Prior achievement ($B = .215$, t =

3.457, $p = .001$), treatment status ($B = -.126$, $t = -2.029$, $p = .044$), and attendance ($B = -.301$, $t = -5.003$, $p < .001$) continued to be significant predictors of Algebra 1 PARCC performance. The implication of these variables is consistent with Model 1. Higher prior achievement is associated with better performance on the Algebra 1 PARCC exam. Better attendance is associated with better performance on the Algebra 1 PARCC exam. Enrollment in T_1 is associated with lower performance on the Algebra 1 PARCC exam when compared to T_0. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.105$, $VIF_{BlackHispanicDummy} = 1.166$, $VIF_{EconDisadDummy} = 1.090$, $VIF_{PriorAchievement} = 1.110$, and $VIF_{Attendance} = 1.037$.

In Model 3, sex and race were both excluded as predictive variables due to the non-significant statuses observed in the previous models. The remaining demographic variable, economically disadvantaged status, continued to be a non-significant predictor of performance on the Algebra 1 PARCC exam ($p = .167$). Prior achievement ($B = .205$, $t = 3.349$, $p = .001$), treatment status ($B = -.136$, $t = -2.221$, $p = .027$), and attendance ($B = -.296$, $t = -4.946$, $p < .001$) all continued to be statistically significant in predicting Algebra 1 PARCC exam outcomes. The directionality of B leads to the same conclusion on the variables' effects as detailed in Models 1 and 2. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.072$, $VIF_{EconDisadDummy} = 1.036$, $VIF_{PriorAchievement} = 1.074$, and $VIF_{Attendance} = 1.030$.

Model 4 eliminated the last demographic variable, economically disadvantaged status, as a predictor due to its non-significant status in previous models. The resultant model included only significant variables. Prior achievement was statistically significant (B = .193, t = 3.18, p = .002) with a positive B-value, indicating that higher prior achievement is associated with higher performance on the Algebra 1 PARCC exam. Prior achievement accounted for 3.7% of the variance in the overall model. Attendance was statistically significant (B = -.299, t = -4.978, p < .001) with a negative B, indicating that an increased number of days absent is associated with a decrease in performance on the Algebra 1 PARCC exam. Attendance accounted for 8.9% of the overall variance of the model, which indicates that it is the strongest contributor. Treatment status was also found to be statistically significant (B = -.143, t = -2.352, p be = .019) with a negative B-value, indicating that enrollment in the treatment group, T_1, and subsequent exposure to the Algebra in eighth grade policy were associated with a decrease in performance on the Algebra 1 PARCC exam. Treatment status accounted for 2% of the variance of the overall model. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.063$, $VIF_{PriorAchievement} = 1.052$, and $VIF_{Attendance} = 1.029$.

Economically Disadvantaged Analysis

In order to answer the first sub-question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Algebra 1 PARCC end-of-course assessment?), an analysis was run on all T_0 and T_1 students who were identified as economically disadvantaged based on their enrollment in the free and reduced lunch program. The same statistical methodology was used to identify which, if any, variables affected these subgroups' performance on the Algebra 1 PARCC exam, excluding the economically disadvantaged status as an independent variable. Descriptive statistics were measured for the economically disadvantaged students in T_1 and T_0 in order to create a profile of each cohort.

Table 16: Economically Disadvantaged T_1 Descriptive Statistics (Algebra)

T1 Economically Disadvantaged Statistics

AlgebraAchievement

N	Valid	24
	Missing	0
Mean		768.17
Median		758.50
Mode		731
Std. Deviation		41.441
Variance		1717.362
Range		141
Minimum		709
Maximum		850

There were 24 students in the T_1 cohort who qualified for the study and were classified as economically disadvantaged based on their enrollment in the free or reduced lunch program. The mean score on the 2016 Algebra PARCC exam for these students was 768.17 with a standard deviation of 41.441. The median score of this cohort was 758.5. The scores ranged from 709 (one student) to a perfect 850 (one student).

Table 17: Economically Disadvantaged T_0 Descriptive Statistics (Algebra)

T0 Economically Disadvantaged Statistics

AlgebraAchievement

N	Valid	38
	Missing	0
Mean		766.95
Median		764.50
Mode		743[a]
Std. Deviation		26.673
Variance		711.457
Range		113
Minimum		711
Maximum		824

a. Multiple modes exist. The smallest value is shown

There were 38 students in the T_0 cohort who qualified for the study and were classified as economically disadvantaged based on their enrollment in the free or reduced lunch program. The mean score on the 2016 Algebra PARCC exam for these students was 766.95 with a standard deviation of 26.673. The median score of this cohort was 764.5. The scores ranged from 711 (one student) to 824 (one student).

The sample size of n = 62 included in the analysis of this sub-question does not meet Field's (2013) threshold of 104 + k, where k is the number of variables included in the study. Since there were five variables included in the regression analysis, a minimum of n = 109 should be met for statistical significance. The following analysis and conclusions drawn from it should be considered with an understanding that the minimum sample size established by Field has not been met.

Table 18: Economically Disadvantaged Group Statistics (Algebra)

Group Statistics

TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean

AlgebraAchievement	1	24	768.17	41.441	8.459
	0	38	766.95	26.673	4.327

Table 19: Economically Disadvantaged Independent Sample T-Test (Algebra)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AlgebraAchievement	Equal variances assumed	9.056	.004	.141	60	.888	1.219	8.636	-16.055	18.494
	Equal variances not assumed			.128	35.116	.899	1.219	9.502	-18.068	20.506

A preliminary comparative means test was run on the two cohorts to identify if any difference in achievement existed. An independent sample t-test was conducted to compare the achievements of students taking Algebra 1 in the eighth grade (T_1) who were classified as economically disadvantaged against those taking it in the ninth grade (T_0) who were classified as economically disadvantaged. The results of the independent sample t-test indicate that there is not a statistically significant difference between the means of these two groups ($p = .888$).

After an initial, independent sample t-test indicated no difference in students' average performance on the Algebra 1 PARCC exam based on the different cohorts, a hierarchical regression analysis was done to identify if the policy had an effect when the analysis was controlled for the exogenous variables other than the economically disadvantaged status that have been identified as affecting math performance. These factors include attendance, race, gender, and prior math achievement. The initial model that was run included all five variables in the study. Subsequent models then removed those variables identified as not having a significant impact on student achievement until an efficient model that was both significant and included only variables that were significant was left. Variables other than the treatment variable were removed individually in order of significance, and the variable with the largest p-value above .05 was removed in each subsequent model.

Table 20: Economically Disadvantaged Variables (Algebra)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, TreatmentStatus, SexDummy, PriorAchievement, BlackHispanicDummy[b]	.	Enter
2	.[b]	SexDummy[c]	Remove
3	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: AlgebraAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, four models were estimated. Model 1 included all the demographic variables other than the economically disadvantaged status, which were used to determine the sample. These variables included attendance measured by the number of days a student missed school, treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all” policy, 0 = member of the T_0 cohort that was not affected by the “algebra for all” policy), sex (dummy coded: 1 = female, 0 = male), prior math achievement measured by a student’s performance on the Math 7 PARCC assessment, and race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic). In Model 2, the sex variable was removed as it was the only variable other than treatment status that was determined to be a non-significant variable in predicting this group of students' achievement on the Algebra 1 PARCC Assessment. Finally, Model 3 dropped the treatment status variable, as it was the only remaining non-significant factor in predicting students' performance on the Algebra 1 PARCC Assessment. The remaining final model included all significant factors that remained and were included in the study: attendance, race, and prior achievement. The dependent variable in all models was performance on the Algebra 1 PARCC Assessment. The sample size consisted of 62 students.

Table 21: Economically Disadvantaged Model Summary (Algebra)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.481[a]	.231	.162	30.071	.231	3.364	5	56	.010
2	.449[b]	.201	.145	30.376	-.030	2.163	1	56	.147
3	.447[c]	.200	.159	30.132	-.001	.073	1	57	.788

a. Predictors: (Constant), Attendance, TreatmentStatus, SexDummy, PriorAchievement, BlackHispanicDummy

b. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy

Model 1, using attendance, treatment status, gender, prior achievement, and race, was a statistically significant predictive model of the dependent variable: performance on the Algebra 1 PARCC Assessment, F-change$_{(5,56)}$ = 3.364, p = .01. An R^2 value of .231 indicates that 23.1%of the variance in Algebra 1 PARCC exam scores of economically disadvantaged students can be explained by the five independent variables that were included. Model 2 removed the gender variable as it was the variable with the highest non-significant p-value other than treatment status. The removal of gender resulted in a decrease in the R^2 value to .201, indicating that 20.1% of the variance in Algebra 1 PARCC scores of economically disadvantaged students in the study can be explained by the four independent variables remaining. This change was found not to be statistically significant, F-change$_{(1,56)}$ = 2.163, p = .147, indicating that the removal of gender as an independent variable did not have a significant effect on the model's predictive power. Finally, treatment status was removed as it was the only remaining non-significant variable left in the model. The removal of treatment status resulted in an R^2 reduction of .001 to .2. However, this change was also found to be non-significant, F-change$_{(1,57)}$ = .073, p = .788. Based on this analysis, attendance, prior achievement, and race are the only significant variables that predict economically disadvantaged students' performance on the Algebra 1 PARCC exam.

An ANOVA analysis indicated that all three models were statistically significant as predictors of performance on the Algebra 1 PARCC exam for the economically disadvantaged students that were included in the study. Model 1, $F_{(5,56)}$ = 3.364, p = .01; Model 2, $F_{(4,57)}$ = 3.591, p =.011; and Model 3, $F_{(3,58)}$ = 4.841, p = .004, are statistically significant. Model 3 is the only model that did not include any non-significant predictor variables.

Table 22: Economically Disadvantaged Coefficients (Algebra)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	498.789	102.585		4.862	.000		
	TreatmentStatus	1.337	7.911	.020	.169	.866	.982	1.018
	SexDummy	11.554	7.857	.177	1.471	.147	.949	1.054
	BlackHispanicDummy	20.048	8.860	.307	2.263	.028	.744	1.344
	PriorAchievement	.353	.135	.333	2.609	.012	.846	1.183
	Attendance	-.831	.319	-.326	-2.605	.012	.876	1.142
2	(Constant)	496.345	103.613		4.790	.000		
	TreatmentStatus	2.157	7.971	.032	.271	.788	.987	1.013
	BlackHispanicDummy	22.178	8.829	.340	2.512	.015	.764	1.308
	PriorAchievement	.361	.136	.340	2.644	.011	.847	1.181
	Attendance	-.790	.321	-.310	-2.459	.017	.883	1.133

3	(Constant)	496.702	102.773		4.833	.000		
	BlackHispanicDummy	21.948	8.717	.337	2.518	.015	.772	1.296
	PriorAchievement	.362	.135	.341	2.672	.010	.847	1.180
	Attendance	-.787	.318	-.309	-2.471	.016	.884	1.131

a. Dependent Variable: AlgebraAchievement

In Model 1, treatment status ($p = .866$) and gender ($p = .147$) were both found to be non-significant predictors of economically disadvantaged students' achievement on the Algebra 1 PARCC exam. Prior achievement ($B = .333$, $t = 2.609$, $p = .012$), race ($B = .307$, $t = 2.263$, $p = .028$), and attendance ($B = -.326$, $t = -2.605$, $p = .012$) were statistically significant predictors of economically disadvantaged students' performance on the Algebra 1 PARCC exam. The positive value of B associated with the prior achievement variable indicates that a higher score on the prior achievement assessment by economically disadvantaged students is associated with a higher score on the Algebra 1 PARCC exam. The positive value for B associated with the race variable indicates that those economically disadvantaged students who identify as black or Hispanic performed better on the Algebra 1 PARCC exam than those who identified as another race. The negative value for B associated with attendance indicates that economically disadvantaged students who were absent more often performed worse on the Algebra 1 PARCC than those who missed less school. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $\text{VIF}_{\text{TreatmentStatus}} = 1.018$, $\text{VIF}_{\text{BlackHispanicDummy}} = 1.344$, $\text{VIF}_{\text{SexDummy}} = 1.054$, $\text{VIF}_{\text{PriorAchievement}} = 1.183$, and $\text{VIF}_{\text{Attendance}} = 1.142$.

In Model 2, sex was excluded as an independent variable based on its non-significant p-value observed in Model 1. Treatment status ($p = .788$) continued to be a non-significant predictive variable for economically disadvantaged students' performance on the Algebra 1 PARCC Assessment. Prior achievement (B = .34, t = 2.644, p = .011), race (B = .34, t = 2.512, p = .015), and attendance (B = -.31, t = -2.459, p = .017) continued to be significant predictors of Algebra 1 PARCC performance by economically disadvantaged students. The implication of these variables is consistent with Model 1: higher prior achievement, better attendance, and identifying as black or Hispanic is associated with better performance on the Algebra 1 PARCC Assessment. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus}$ = 1.013, $VIF_{BlackHispanicDummy}$ = 1.308, $VIF_{PriorAchievement}$ = 1.18, and $VIF_{Attendance}$ = 1.133.

In Model 3, sex and treatment status were both excluded as predictive variables due to their non-significant status observed in the previous models. The remaining variables, prior achievement (B = .341, t = 2.672, p = .01), race (B = .337, t = 2.518, p = .015) and attendance (B = -.309, t = -2.471, p =.016), all continued to be statistically significant in predicting Algebra 1 PARCC outcomes for economically disadvantaged students. Prior achievement accounted for 11.6% of the variance in the overall model, indicating that it is the strongest contributor. Race accounted for 11.4% of the variance in the overall model. Attendance accounted for 9.6% of the variance in the overall model. The directionality of B leads to the same conclusion regarding the the variables' effects, as detailed in Models 1 and 2. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): VIF_{Race} = 1.296, $VIF_{PriorAchievement}$ = 1.18, and $VIF_{Attendance}$ = 1.131.

Black and Hispanic Analyses

In order to answer the second sub-question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?), an analysis was run on all eligible members of cohort T_0 and T_1 who identified themselves as black or Hispanic when enrolling in the district. The same statistical methodology was used to identify which, if any, variables affected this subgroup's performance on the Algebra 1 PARCC Assessment, excluding the race variable, which was used to identify the sample. Descriptive statistics were run for the black and Hispanic students in T_1 and T_0 in order to create a profile of each cohort.

Table 23: Black and Hispanic T_1 Descriptive Statistics

T1 Black and Hispanic Statistics

AlgebraAchievement

N	Valid	22
	Missing	0
Mean		778.59
Median		776.50
Mode		689[a]
Std. Deviation		41.705
Variance		1739.301
Range		161
Minimum		689
Maximum		850

a. Multiple modes exist. The smallest value is shown

There were 22 students in the T_1 cohort who qualified for the study and were classified as black or Hispanic based on self-identification at the time of enrollment in the district. The mean score on the 2016 Algebra PARCC exam for these students was 778.59 with a standard deviation of 41.705. The median score of this cohort was 776.5. The scores ranged from 689 (one student) to a perfect 850 (one student).

Table 24: Black and Hispanic T_0 Descriptive Statistics (Algebra)

T0 Black and Hispanic

Statistics

AlgebraAchievement

N	Valid	47
	Missing	0
Mean		758.06
Median		761.00
Mode		711[a]
Std. Deviation		31.124
Variance		968.713
Range		142
Minimum		682
Maximum		824

a. Multiple modes exist. The smallest value is shown

There were 47 students in the T_0 cohort who qualified for the study and were classified as black or Hispanic based on self-identification at the time of enrollment in the district. The mean score on the 2016 Algebra PARCC exam for these students was 758.06 with a standard deviation of 31.124. The median score of this cohort was 761. The scores ranged from 682 (one student) to 824 (one student).

The sample size of n = 69 included in the analysis of this sub-question does not meet Field’s (2013) threshold of 104 + k, where k is the number of variables included in the study. Since there are five variables included in the regression analysis, a minimum of n = 109 should be met for statistical significance. The following analysis and conclusions drawn from this analysis should be considered with the understanding that the minimum sample size established by Field has not been met.

Table 25: Black and Hispanic Group Statistics (Algebra)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
AlgebraAchievement	1	22	778.59	41.705	8.892
	0	47	758.06	31.124	4.540

Table 26: Black and Hispanic Independent Sample T-Test (Algebra)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AlgebraAchievement	Equal variances assumed	3.856	.054	2.284	67	.026	20.527	8.987	2.590	38.465
	Equal variances not assumed			2.056	32.372	.048	20.527	9.983	.201	40.854

A preliminary comparative means test was run on the two cohorts to identify if a difference in achievement existed. An independent sample t-test was conducted to compare the achievement of black and Hispanic students taking Algebra 1 in the eighth grade (T_1) against those taking it in the ninth grade (T_0). The results of the independent sample t-test indicate that there is a statistically significant difference between the cohorts' performance on the Algebra 1 PARCC exam ($t_{(67)} = 2.284$, $p = .026$, two-tailed). The black and Hispanic students who were unaffected by the policy and therefore took Algebra 1 in the ninth grade (M = 758.06, SD =

31.124, N = 47) scored worse on the Algebra 1 PARCC exam than those black and Hispanic students who took Algebra 1 in the eighth grade as a result of the policy (M = 778.59, SD = 41.705, N = 22). The recorded mean difference of 20.527 demonstrates that, on average, black and Hispanic students who were affected by the policy and took Algebra 1 in the eighth grade scored about 20 points higher on the PARCC exam than their ninth-grade counterparts, with a 95% confidence interval of the difference, placing this difference in performance between 2.59 points and 38.465 points.

After an initial, independent sample t-test, indicated a difference in the average performance on the Algebra 1 PARCC by black and Hispanic students in different cohorts, a hierarchical regression analysis was performed to identify the effect of the policy on students when controlling for exogenous variables other than race that have been identified as having an effect on math performance: attendance, socioeconomic status, gender, and prior math achievement. An initial model was run and included all five of these variables. Subsequent models then removed those variables identified as not having a significant impact on black and Hispanic student achievement until an efficient model that was both significant and included only variables that were significant was left. Variables were removed individually in order of significance; the variable, excluding treatment status, with the largest p-value above .05 was removed in each subsequent model.

Table 27: Black and Hispanic Variables (Algebra)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method

1	Attendance, TreatmentStatus, EconDisadDummy, SexDummy, PriorAchievement[b]	.	Enter
2	.[b]	SexDummy[c]	Remove

a. Dependent Variable: AlgebraAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, two models were estimated. Model 1 included all five of the potentially significant predictive variables on Algebra 1 performance, other than race, that were included in the study: sex (dummy coded: 1 = female, 0 = male), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all” policy, 0 = member of T_0 cohort that was not affected by the “algebra for all” policy), attendance, and prior math achievement. In Model 2, the sex variable was removed, leaving four variables as predictors of Algebra 1 performance. The dependent variable in each model was Algebra 1 achievement, measured by student performance on the 15-16 Algebra 1 PARCC Assessment. The sample size consisted of 69 students.

Table 28: Black and Hispanic Model Summary (Algebra)

Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	Change Statistics: R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.696[a]	.484	.443	26.745	.484	11.837	5	63	.000
2	.696[b]	.484	.452	26.551	-.001	.073	1	63	.788

a. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, SexDummy, PriorAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

Model 1, using attendance, treatment status, gender, prior achievement, and economically disadvantaged status, was a statistically significant predictive model of the dependent variable: performance on the Algebra 1 PARCC Assessment, F-change$_{(5,63)}$ = 11.837, $p < .001$. An R^2 value of .484 indicates that 48.4% of the variance in Algebra 1 PARCC exam scores for black and Hispanic students can be explained by the five independent variables that were included. Model 2 removed the gender variable as it was the only variable with a non-significant p-value ($p = .788$). The removal of gender resulted in a decrease in the R^2 value of less than .001, indicating that 48.4% of the variance in Algebra 1 PARCC scores for black and Hispanic students in the study can still be explained by the four independent variables remaining. This change was found to not be statistically significant, F-change$_{(1,63)}$ = .073, $p = .788$, indicating that the removal of gender as an independent variable did not have a significant effect on the model's predictive power. Based on this analysis, attendance, prior achievement, economically disadvantaged status, and exposure to the "algebra for all" policy are all significant variables in predicting black and Hispanic students' performance on the Algebra 1 PARCC Assessment.

An ANOVA analysis indicated that both models were statistically significant as predictors of Algebra 1 PARCC performance for the black and Hispanic students that were included in the study. Model 1, $F_{(5,63)} = 11.837$, $p < .001$ and Model 2, $F_{(4,64)} = 14.995$, $p < .001$, are statistically significant. Model 2 is the only model that did not include any non-significant predictor variables.

Table 29: Black and Hispanic Coefficients (Algebra)

Coefficients[a]

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Collinearity Statistics

		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	425.082	83.925		5.065	.000		
	TreatmentStatus	17.166	6.980	.225	2.459	.017	.980	1.021
	SexDummy	-1.850	6.843	-.026	-.270	.788	.895	1.118
	EconDisadDummy	21.227	6.695	.296	3.170	.002	.941	1.063
	PriorAchievement	.458	.109	.414	4.186	.000	.835	1.198
	Attendance	-.979	.243	-.393	-4.036	.000	.863	1.159
2	(Constant)	418.324	79.535		5.260	.000		
	TreatmentStatus	16.971	6.892	.222	2.462	.017	.990	1.010
	EconDisadDummy	21.225	6.646	.296	3.193	.002	.941	1.063
	PriorAchievement	.466	.105	.421	4.432	.000	.893	1.120
	Attendance	-.964	.234	-.387	-4.115	.000	.912	1.097

a. Dependent Variable: AlgebraAchievement

In Model 1, gender ($p = .788$) was found to be a non-significant predictor of black and Hispanic students' achievement on the Algebra 1 PARCC Assessment. Prior achievement ($B = .414$, $t = 4.186$, $p < .001$), treatment status ($B = .225$, $t = 2.459$, $p = .017$), economically disadvantaged status ($B = .296$, $t = 3.17$, $p = .002$), and attendance ($B = -.393$, $t = -4.036$, $p < .001$) were statistically significant predictors of back and Hispanic students' performance on the Algebra 1 PARCC Assessment. The positive value of B associated with the prior achievement variable indicates that a higher score on the prior achievement assessment by black and Hispanic students is associated with a higher score on the Algebra 1 PARCC exam. The positive value for B associated with the treatment status variable indicates that those black and Hispanic who were members of T_1 and therefore took Algebra in the eighth grade performed better than those who were unaffected by the Algebra in eighth grade policy and took the course in the ninth grade. The positive value of B associated with the economically disadvantaged status variable indicates that those black and Hispanic students that were identified as economically disadvantaged due to their enrollment in the free or reduced lunch program performed better than those who were not identified as economically disadvantaged. The negative value for B associated with attendance indicates that black and Hispanic students who were absent more often performed worse on the Algebra 1 PARCC exam than those who missed less school. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF^{-}_{TreatmentStatus} = 1.021$, $VIF_{SexDummy} = 1.118$, $VIF_{EconDisadDummy} = 1.063$, $VIF_{PriorAchievement} = 1.198$, and $VIF_{Attendance} = 1.159$.

In Model 2, sex was excluded as an independent variable based on its non-significant p-value observed in Model 1 ($p = .788$). Treatment status ($B = .222$, $t = 2.462$, $p = .017$) prior achievement ($B = .421$, $t = 4.432$, $p < .001$), economically disadvantaged status ($B = .296$, $t = 3.193$, $p = .002$), and attendance ($B = -.387$, $t = -4.115$, $p < .001$) continued to be significant predictors of black and Hispanic students' performance on the assessment. Treatment status accounted for 4.9% of the variance of the overall model. Prior achievement accounted for 17.7% of the variance of the overall model, indicating that it is the strongest contributor. Socioeconomic status accounted for 8.8% of the variance to the overall model. Attendance accounted for 15% of the variance to the overall model. The implications of these variables is consistent with Model 1: taking Algebra in the eighth grade as a result of the new policy, higher prior achievement, better attendance, and being identified as economically disadvantaged is associated with better performance by black and Hispanic students on the Algebra 1 PARCC Assessment. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.01$, $VIF_{EconDisadDummy} = 1.063$, $VIF_{PriorAchievement} = 1.12$, and $VIF_{Attendance} = 1.097$.

Female Analysis

In order to answer the third sub-question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?) an analysis was run on all T_0 and T_1 students who identified themselves as female when enrolling in the district. The same statistical methodology was used to identify which, if any, variables affected this subgroup's performance on the Algebra 1 PARCC Assessment, excluding gender as an independent variable. Descriptive statistics were measured for the economically disadvantaged students in T_1 and T_0 in order to create a profile of each cohort.

Table 30: Female T_1 Descriptive Statistics Algebra

T1 Female Statistics

AlgebraAchievement

N	Valid	54
	Missing	0
Mean		760.30
Median		757.00
Mode		742
Std. Deviation		38.896
Variance		1512.929
Range		188
Minimum		662
Maximum		850

There were 54 female students in the T_1 cohort who qualified for the study. The mean score on the 2016 Algebra PARCC exam for these students was 760.3 with a standard deviation of 38.896. The median score of this cohort was 757. The scores ranged from 662 (one student) to a perfect 850 (one student).

Table 31: Female T_0 Descriptive Statistics (Algebra)

T0 Female Statistics

AlgebraAchievement

N	Valid	62
	Missing	0
Mean		768.85
Median		768.00
Mode		768[a]
Std. Deviation		29.675
Variance		880.585
Range		139
Minimum		711
Maximum		850

a. Multiple modes exist. The smallest value is shown

There were 62 female students in the T_0 cohort who qualified for the study. The mean score on the 2016 Algebra PARCC exam for these students was 768.85 with a standard deviation of 29.675. The median score of this cohort was 768. The scores ranged from 711 (one student) to a perfect 850 (one student).

Table 32: Female Group Statistics (Algebra)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
AlgebraAchievement	1	54	760.30	38.896	5.293
	0	62	768.85	29.675	3.769

Table 33: Female Independent Sample T-Tests (Algebra)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AlgebraAchievement	Equal variances assumed	4.726	.032	-1.342	114	.182	-8.559	6.379	-21.196	4.079
	Equal variances not assumed			-1.317	98.387	.191	-8.559	6.498	-21.452	4.335

A preliminary comparative means test was run on the two cohorts to identify if a difference in achievement existed. An independent sample t-test was conducted to compare the achievement of female students taking Algebra 1 in the eighth grade (T_1) against those taking it in the ninth grade (T_0). The results of the independent sample t-test indicate that there is not a statistically significant difference in the means of these two groups ($p = .182$).

After an initial, independent sample t-test indicated no difference between the two cohorts of female students' average performance on the Algebra 1 PARCC exam, a hierarchical regression analysis was performed to determine whether the policy had an effect when the exogenous variables, other than gender, that have been identified as affecting math performance were controlled for. These variables included attendance, race, economically disadvantaged status, and prior math achievement. An initial model was run and included all five variables. Subsequent models then removed those variables identified as not having a significant impact on female student achievement until an efficient model that was both significant and included only variables that were significant was left. Variables other than the treatment variable were removed individually in order of significance. The variable with the largest p-value above .05 was removed in each subsequent model.

Table 34: Female Variables (Algebra)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, BlackHispanicDummy, TreatmentStatus, EconDisadDummy, PriorAchievement[b]	.	Enter
2	.[b]	BlackHispanicDummy[c]	Remove
3	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: AlgebraAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, three models were estimated. Model 1 included all the demographic variables other than gender, which was used to determine the sample. These variables included attendance measured by the number of days a student missed school, race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all” policy, 0 = member of the T_0 cohort that was not affected by the algebra for all policy), and prior math achievement measured by performance on the Math 7 PARCC assessment. In Model 2, the race variable was removed as it was the only variable other than treatment status that was determined to be a non-significant variable in predicting achievement for this group of students on the Algebra 1 PARCC Assessment. Finally, Model 3 dropped the treatment status variable, as it was the only remaining non-significant factor in predicting performance on the Algebra 1 PARCC Assessment. The remaining final model included all significant factors that remained and that were included in the study: attendance, economically disadvantaged status, and prior achievement. The dependent variable in all models was performance on the Algebra 1 PARCC Assessment. The sample size consisted of 116 students.

Table 35: Female Model Summary (Algebra)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.518[a]	.268	.235	30.083	.268	8.059	5	110	.000
2	.518[b]	.268	.242	29.949	.000	.013	1	110	.911
3	.505[c]	.255	.235	30.071	-.013	1.918	1	111	.169

a. Predictors: (Constant), Attendance, BlackHispanicDummy, TreatmentStatus, EconDisadDummy, PriorAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

c. Predictors: (Constant), Attendance, EconDisadDummy, PriorAchievement

Model 1, using attendance, treatment status, economically disadvantaged status, prior achievement, and race, was a statistically significant predictive model of the dependent variable: performance on the Algebra 1 PARCC Assessment, F-change$_{(5,110)}$ = 8.059, $p < .001$. An R^2 value of .268 indicates that 26.8% of the variance in Algebra 1 PARCC exam scores for female students can be explained by the five independent variables that were included. Model 2 removed the race variable as it was the variable with the highest non-significant p-value other than treatment status. The removal of race resulted in a decrease in the R^2 value of less than .001, meaning there was no measurable change in the percent of variance in female performance on the Algebra 1 PARCC in the model including the other four variables. This change was found not to be statistically significant, F-change$_{(1,110)}$ = .013, p = .1911, indicating that the removal of race as an independent variable did not have a significant effect on the model's predictive power. Finally, treatment status was removed as it was the only remaining non-significant variable left in the model. The removal of treatment status resulted in an R^2 reduction to .255, indicating that 25.5% of variance in females performance on the Algebra 1 PARCC can be explained by these variables. However, this change was also found to be non-significant, F-change$_{(1,111)}$ = 1.918, p = .169. Based on this analysis, attendance, prior achievement, and economically disadvantaged status are the only significant variables in predicting females performance on the Algebra 1 PARCC Assessment.

An ANOVA analysis indicated that all three models were statistically significant as predictors of female students' performance on the Algebra 1 PARCC exam. Model 1, $F_{(5,110)}$ = 8.059, p < .001; Model 2, $F_{(4,111)}$ = 10.162, p < .001; and Model 3, $F_{(3,112)}$ = 12.805, p < .001, were statistically significant. Model 3 is the only model that did not include any non-significant predictor variables.

Table 36: Female Coefficients (Algebra)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	587.244	68.313		8.596	.000		
	TreatmentStatus	-8.052	5.825	-.117	-1.382	.170	.924	1.082
	BlackHispanicDummy	-.747	6.672	-.010	-.112	.911	.796	1.257
	EconDisadDummy	16.973	6.847	.215	2.479	.015	.888	1.127
	PriorAchievement	.254	.089	.256	2.842	.005	.819	1.221
	Attendance	-1.138	.254	-.377	-4.473	.000	.935	1.070
2	(Constant)	584.626	63.896		9.150	.000		
	TreatmentStatus	-8.022	5.793	-.117	-1.385	.169	.926	1.080
	EconDisadDummy	16.747	6.513	.212	2.571	.011	.972	1.029

	PriorAchievement	.257	.084	.259	3.047	.003	.910	1.099
	Attendance	-1.136	.252	-.377	-4.502	.000	.943	1.061
3	(Constant)	601.674	62.955		9.557	.000		
	EconDisadDummy	17.144	6.534	.217	2.624	.010	.974	1.027
	PriorAchievement	.231	.083	.232	2.793	.006	.960	1.041
	Attendance	-1.196	.249	-.397	-4.794	.000	.972	1.029

a. Dependent Variable: AlgebraAchievement

In Model 1, treatment status ($p = .17$) and race ($p = .911$) were both found to be non-significant predictors of female students' achievement on the Algebra 1 PARCC exam. Prior achievement ($B = .256$, $t = 2.842$, $p = .005$), economically disadvantaged status ($B = .215$, $t = 2.479$, $p = .015$), and attendance ($B = -.377$, $t = -4.473$, $p < .001$) were statistically significant predictors of Algebra 1 PARCC performance by females. The positive value of B associated with the prior achievement variable indicates that a higher score on the prior achievement assessment by female students is associated with a higher score on the Algebra 1 PARCC exam. The positive value for B associated with the economically disadvantaged variable indicates that female students who were identified as economically disadvantaged performed better on the Algebra 1 PARCC exam than female students who were not economically disadvantaged. The negative value for B associated with attendance indicates that female students who were absent more often performed worse on the Algebra 1 PARCC exam than those who missed less school. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.082$, $VIF_{BlackHispanicDummy} = 1.257$, $VIF_{EconDisadDummy} = 1.127$, $VIF_{PriorAchievement} = 1.221$, and $VIF_{Attendance} = 1.070$.

In Model 2, race was excluded as an independent variable based on its non-significant p-value observed in Model 1. Treatment status ($p = .169$) continued to be a non-significant predictive variable for female students' performance on the Algebra 1 PARCC exam. Prior achievement ($B = .259$, $t = 3.047$, $p = .003$), economically disadvantaged status ($B = .212$, $t = 2.571$, $p = .011$), and attendance ($B = -.377$, $t = -4.502$, $p < .001$) continued to be significant predictors of females' performance on the Algebra 1 PARCC exam. The implication of these variables is consistent with Model 1: higher prior achievement, better attendance, and being economically disadvantaged are associated with better performance on the Algebra 1 PARCC for females. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.080$, $VIF_{EconDisadDummy} = 1.029$, $VIF_{PriorAchievement} = 1.099$, and $VIF_{Attendance} = 1.061$.

In Model 3, race and treatment status were both excluded as predictive variables due to their non-significant status observed in the previous models. The remaining variables, prior achievement ($B = .232$, $t = 2.793$, $p = .006$), economically disadvantaged status ($B = .217$, $t = 2.624$, $p = .01$), and attendance ($B = -.397$, $t = -4.794$, $p < .001$), all continued to be statistically significant in predicting Algebra 1 PARCC outcomes for female students. Prior achievement accounted for 5.4% of the variance of the overall model. Socioeconomic status accounted for 4.7% of the variance of the overall model. Attendance accounted for 15.8% of the variance of the overall model, which indicates that it is the strongest contributor. The directionality of B leads to the same conclusion regarding the variables' effects as detailed in Models 1 and 2. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{EconDisadDummy}$ = 1.027, $VIF_{PriorAchievement}$ = 1.041, and $VIF_{Attendance}$ = 1.029.

Male Analyses

In order to answer the fourth sub-question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?), an analysis was run on all T_0 and T_1 students who identified themselves as male when enrolling in the district. The same statistical methodology was used to identify which, if any, variables affected this subgroup's performance on the Algebra 1 PARCC Assessment, excluding gender as an independent variable. Descriptive statistics were measured for the economically disadvantaged students in T_1 and T_0 in order to create a profile of each cohort.

Table 37: Male T_1 Descriptive Statistics (Algebra)

T1 Male Statistics

AlgebraAchievement

N	Valid	67
	Missing	0
Mean		756.00
Median		760.00
Mode		754[a]
Std. Deviation		37.417
Variance		1400.000
Range		176
Minimum		669
Maximum		845

a. Multiple modes exist. The smallest value is shown

There were 67 male students in the T_1 cohort who qualified for the study. The mean score on the 2016 Algebra PARCC exam for these students was 756 with a standard deviation of 37.417. The median score of this cohort was 760. The scores ranged from 669 (one student) to 845 (one student).

Table 38: Male T_0 Descriptive Statistics (Algebra)

T0 Male Statistics

AlgebraAchievement

N	Valid	62
	Missing	0
Mean		766.77
Median		765.00
Mode		758[a]
Std. Deviation		30.128
Variance		907.719
Range		154
Minimum		682
Maximum		836

a. Multiple modes exist. The smallest value is shown

There were 62 male students in the T_0 cohort who qualified for the study. The mean score on the 2016 Algebra PARCC exam for these students was 766.77 with a standard deviation of 30.128. The median score of this cohort was 765. The scores ranged from 682 (one student) to 836 (one student).

Table 39: Male Group Statistics (Algebra)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
AlgebraAchievement	1	67	756.00	37.417	4.571

	0	62	766.77	30.128	3.826

Table 40: Male Independent Sample T-Test (Algebra)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AlgebraAchievement	Equal variances assumed	2.703	.103	-1.792	127	.075	-10.774	6.011	-22.669	1.121
	Equal variances not assumed			-1.807	124.669	.073	-10.774	5.961	-22.572	1.024

A preliminary comparative means test was run on the two cohorts to identify whether a difference in achievement existed. An independent sample t-test was conducted to compare the achievement of those male students taking Algebra 1 in the eighth grade (T_1) against those taking it in the ninth grade (T_0). The results of the independent sample t-test indicate that there is no statistically significant difference between the means of these two groups ($p = .075$).

After an initial independent sample t-test indicated no difference in the average performance on the Algebra 1 PARCC by male students in different cohorts, a hierarchical regression analysis was performed to identify whether the policy had an effect when the exogenous variables, other than gender, that have been identified as affecting math performance were controlled for. These variables included attendance, race, economically disadvantaged status, and prior math achievement. An initial model was run and included all five variables. Subsequent models then removed those variables identified as not having a significant impact on female student achievement until an efficient model that was both significant and included only variables that were significant was left. Variables other than the treatment variable were removed individually in order of significance. The variable with the largest p-value above .05 was removed in each subsequent model.

Table 41: Male Variables (Algebra)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, PriorAchievement, BlackHispanicDummy, EconDisadDummy, TreatmentStatus[b]	.	Enter
2	.[b]	EconDisadDummy[c]	Remove
3	.[b]	BlackHispanicDummy[c]	Remove
4	.[b]	PriorAchievement[c]	Remove
5	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: AlgebraAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, five models were estimated. Model 1 included all the demographic variables other than gender, which was used to determine the sample. These variables included attendance measured by the number of days a student missed school, race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all” policy, 0 = member of the T_0 cohort that was not affected by the “algebra for all” policy), and prior math achievement measured by students’ performance on the Math 7 PARCC assessment. In Model 2, the economically disadvantaged status was the variable, other than treatment, that had the highest p-value in the model (p = .715). In Model 3, all variables from Model 2 were retained other than the race variable, as this was the variable, other than treatment, that had the highest p-value (p = .376). In Model 4, all the variables from Model 3 were retained other than prior achievement, as this was the variable, other than treatment, with the highest p-value (p = .103). Finally, treatment status was removed, leaving Model 5 with only attendance as a predictive variable of Algebra 1 achievement. This was the only variable found to be a statistically significant predictor of Algebra 1 achievement in males in any of the models. The dependent variable in all models was performance on the Algebra 1 PARCC Assessment. The sample size consisted of 129 students.

Table 42: Male Model Summary (Algebra)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.349[a]	.122	.086	32.887	.122	3.416	5	123	.006
2	.348[b]	.121	.093	32.772	-.001	.134	1	123	.715
3	.340[c]	.115	.094	32.745	-.006	.790	1	124	.376
4	.310[d]	.096	.082	32.965	-.019	2.704	1	125	.103
5	.285[e]	.081	.074	33.105	-.015	2.075	1	126	.152

a. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy, EconDisadDummy, TreatmentStatus

b. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy, TreatmentStatus

c. Predictors: (Constant), Attendance, PriorAchievement, TreatmentStatus

d. Predictors: (Constant), Attendance, TreatmentStatus

e. Predictors: (Constant), Attendance

Model 1, using attendance, treatment status, economically disadvantaged status, prior achievement, and race, was a statistically significant predictive model of the dependent variable:

performance on the Algebra 1 PARCC Assessment by male students, F-change$_{(5,123)}$ = 3.416, p = .006. An R^2 value of .122 indicates that 12.2% of the variance in Algebra 1 PARCC exam scores for male students can be explained by the five independent variables that were included. Model 2 removed the economically disadvantaged status variable as it was the variable with the highest non-significant p-value other than treatment status. The removal of economically disadvantaged resulted in a decrease in the R^2 value of .00, meaning that 12.1% of the variance in Algebra 1 PARCC performance by males can be explained by the remaining four variables. This change was found to not be statistically significant, F-change$_{(1,123)}$ = .134, p = .715, indicating that the removal of economically disadvantaged status as an independent variable did not have a significant effect on the model's predictive power. Model 3 removed the race variable from Model 2 as it was the variable with the highest non-significant p-value other than treatment status. The removal of race resulted in an R^2 value of .115, meaning that 11.5% of the variance in Algebra 1 PARCC performance by males can be explained by the remaining three variables. This change was found not to be statistically significant, F-change$_{(1,124)}$ = .79, p = .376, indicating that the removal of race as an independent variable did not have a significant effect on the model's predictive power. Model 4 removed the prior achievement variable from Model 3 as it was the variable with the highest non-significant p-value other than treatment status. The removal of prior achievement resulted in an R^2 value of .096, meaning that 9.6% of the variance in Algebra 1 PARCC performance by males can be explained by the remaining two variables: attendance and treatment status. This change was found not to be statistically significant, F-change$_{(1,125)}$ = 2.704, p = .103, indicating that the removal of prior as an independent variable did not have a significant effect on the model's predictive power. Finally, treatment status was removed as it was the only remaining non-significant variable left in the analysis. The removal of treatment status resulted in an R^2 reduction to .081, indicating that 8.1% of the variance in males' performance on the Algebra 1 PARCC can be explained by attendance. However, this change was also found to be non-significant, F-change$_{(1,126)}$ = 2.075, p = .152. Based on this analysis, attendance is the only significant variable in predicting males' performance on the Algebra 1 PARCC Assessment.

An ANOVA analysis indicated that all five models were statistically significant as predictors of Algebra 1 PARCC performance for the male students that were included in the study. Model 1, $F_{(5,123)}$ = 3.416, p = .006; Model 2, $F_{(4,124)}$ = 4.267, p = .003, Model 3, $F_{(3,125)}$ = 5.435, p = .002;Model 4, $F_{(2,126)}$ = 6.71, p = .002; and Model 5, $F_{(1,127)}$ = 11.249, p = .001, were statistically significant. Model 5 is the only model that did not include any non-significant predictor variables.

Table 43: Male Coefficients (Algebra)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	654.270	72.943		8.970	.000		
	TreatmentStatus	-8.760	6.253	-.128	-1.401	.164	.859	1.164
	BlackHispanicDummy	6.884	7.351	.086	.936	.351	.850	1.176
	EconDisadDummy	-2.551	6.970	-.032	-.366	.715	.907	1.103
	PriorAchievement	.157	.096	.142	1.634	.105	.940	1.064
	Attendance	-.619	.194	-.279	-3.193	.002	.933	1.071
2	(Constant)	649.747	71.637		9.070	.000		
	TreatmentStatus	-8.565	6.209	-.125	-1.380	.170	.865	1.156
	BlackHispanicDummy	6.405	7.208	.080	.889	.376	.878	1.139

	PriorAchievement	.162	.095	.147	1.708	.090	.959	1.043
	Attendance	-.610	.192	-.275	-3.184	.002	.950	1.053
3	(Constant)	656.796	71.137		9.233	.000		
	TreatmentStatus	-10.221	5.917	-.149	-1.727	.087	.951	1.052
	PriorAchievement	.155	.094	.141	1.644	.103	.965	1.036
	Attendance	-.580	.188	-.261	-3.077	.003	.981	1.020
4	(Constant)	773.526	4.701		164.561	.000		
	TreatmentStatus	-8.435	5.856	-.123	-1.440	.152	.984	1.016
	Attendance	-.598	.189	-.270	-3.159	.002	.984	1.016
5	(Constant)	769.604	3.848		200.010	.000		
	Attendance	-.632	.189	-.285	-3.354	.001	1.000	1.000

a. Dependent Variable: AlgebraAchievement

In Model 1, treatment status (p = .164), race (p = .351), economically disadvantaged status (p = .715), and prior achievement (p = .105) were all found to be non-significant predictors of Algebra 1 PARCC performance by male students. Only attendance (B = -.279, t = -3.139, p = .002) was found to be a significant predictive variable. The negative value of B indicates that male students with more days absent perform worse on the Algebra 1 PARCC than those with less. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus}$ = 1.164, $VIF_{BlackHispanicDummy}$ = 1.176, $VIF_{EconDisadDummy}$ = 1.103, $VIF_{PriorAchievement}$ = 1.064, and $VIF_{Attendance}$ = 1.071.

In Model 2, treatment status (p = .17), race (p = .376) and prior achievement (p = .09) continued to be non-significant predictors males' performance on the Algebra 1 PARCC Assessment. Only attendance (B = -.275, t = -3.184, p = .002) was found to be a significant predictive variable. The negative value of B indicates that male students with more days absent perform worse on the Algebra 1 PARCC than those with less. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013):

$VIF_{TreatmentStatus} = 1.156$, $VIF_{BlackHispanicDummy} = 1.139$, $VIF_{PriorAchievement} = 1.043$, and $VIF_{Attendance} = 1.053$.

In Model 3, treatment status (p = .087) and prior achievement (p = .103) continued to be non-significant predictors of male students' performance on the Algebra 1 PARCC Assessment. Only attendance (B = -.231, t = -3.077, p = .003) was found to be a significant predictive variable. The negative value of B indicates that male students with more days absent perform worse on the Algebra 1 PARCC than those with less. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.052$, $VIF_{PriorAchievement} = 1.036$, and $VIF_{Attendance} = 1.02$.

In Model 4, treatment status (p = .152) continued to be a non-significant predictor of males' performance on the Algebra 1 PARCC exam. Only attendance (B = -.27, t = -3.159, p = .002) was found to be a significant predictive variable. The negative value of B indicates that male students with more days absent perform worse on the Algebra 1 PARCC than those with less. There are no concerns regarding collinearity or multicollinearity as the VIF did not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.016$ and $VIF_{Attendance} = 1.016$.

In Model 5, attendance (B = -.270, t = -3.159, p = .002) was found to be a significant predictive variable. It accounted for 7.3% of the variance of the overall model. The negative value of B indicates that male students with more days absent perform worse on the Algebra 1 PARCC Assessment than those with less days. There are no concerns regarding collinearity or multicollinearity as only one variable was included.

2017 Geometry PARCC Assessment

The second phase of the study seeks to examine the effect of the Algebra for everyone in eighth grade policy on future outcomes based on the second main research question: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by student performance on the Geometry PARCC end-of-course assessment? All students, whether or not they were exposed to the policy, take Geometry after Algebra 1. This phase of the study seeks to identify the effect, if any, that the policy has on Geometry performance for all cohorts, as well as all of the subgroups that were analyzed in the first phase of the study, divided based on race, gender, and socioeconomic status.

Full Cohort Analyses

The second, main research question is answered based on a full cohort analysis, which compares students who were exposed to the "algebra for all" in eighth grade policy against those who were not, using their performance on the Geometry PARCC as a measure of future success in math. All eligible members of T_1 and T_0 were included in this analysis. Descriptive statistics were measured for each cohort in order to create a profile of the groups being studied.

Table 44: Full Cohort T_1 Descriptive Statistics (Geometry)

T1 Statistics

GeometryAchievement

N	Valid	110
	Missing	0
Mean		740.78
Median		743.00
Mode		748
Std. Deviation		31.156
Variance		970.723
Range		154

Minimum	663
Maximum	817

There were 110 students in the T_1 cohort who met the requirements for being included in the study. The mean score on the 2017 Geometry PARCC exam for these students was 740.78 with a standard deviation of 31.156. The median score for this cohort was 743. The scores ranged across 154 points, with the lowest being 663 (one student) and the highest being 817 (one student).

Table 45: Full Cohort T_0 Descriptive Statistics (Geometry)

T0 Statistics

GeometryAchievement

N	Valid	115
	Missing	0
Mean		741.32
Median		734.00
Mode		719
Std. Deviation		32.911
Variance		1083.150
Range		168
Minimum		680
Maximum		848

There were 115 students in the T_0 cohort who met the requirements for being included in the study. The mean score on the 2017 Geometry PARCC exam for this group of students was 741.32 with a standard deviation of 32.911. The median score for this cohort was 734. The scores ranged across 168 points, from a low of 680 (one student) to a high of 848 (one student).

Table 46: Full Cohorts Group Statistics (Geometry)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
GeometryAchievement	1	110	740.78	31.156	2.971
	0	115	741.32	32.911	3.069

Table 47: Full Cohorts Independent Sample T-Test (Geometry)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GeometryAchievement	Equal variances assumed	.010	.920	-.126	223	.900	-.540	4.276	-8.967	7.888
	Equal variances not assumed			-.126	222.977	.900	-.540	4.271	-8.957	7.877

For a determination of whether a mean difference existed, a preliminary independent sample t-test was run, comparing the 2017 Geometry PARCC of students who were subject to the “algebra for all” in eighth grade policy (T_1) against those students who took Algebra in the ninth grade (T_0). The results of the independent sample t-test indicate that there is not a statistically significant difference between the two cohorts’ performance on the 2017 Geometry PARCC exam ($p = .900$).

After the initial independent sample t-test resulted in no statistically significant difference in average performance on the 2017 Geometry PARCC exam by T_1 and T_0 students, a hierarchical regression analysis was performed to identify the effect of the policy on other exogenous demographic variables including race, gender, attendance, prior achievement, and socioeconomic status. An initial model was run including all six variables (the five exogenous variables included in the study and treatment status). Subsequent models removed any variables found to be non-significant in order of p-value until only significant variables remained to identify the effect of treatment when these other variables were controlled for, as well as to identify the effect of the other variables on their own. The variable with the larges p-value above .05 was removed to create each progressive model.

Table 48: Full Cohorts Variables (Geometry)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	BlackHispanicDummy, SexDummy, TreatmentStatus, Attendance, PriorAchievement, EconDisadDummy[b]	.	Enter
2	.[b]	BlackHispanicDummy[c]	Remove
3	.[b]	EconDisadDummy[c]	Remove
4	.[b]	SexDummy[c]	Remove
5	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: GeometryAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, five models were estimated. Model 1 consisted of all six variables included in the study: race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), sex (dummy coded: 1 = female, 0 = male), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all" policy, 0 = member of T_0 cohort that was not affected by the "algebra for all" policy), attendance, and prior math achievement. In Model 2, the race variable was removed, leaving treatment status and the other four exogenous variables. Model 3 removed the economically disadvantaged variable, leaving treatment status, sex, attendance, and prior achievement as predictors of Geometry achievement. Model 4 dropped gender, leaving prior achievement, attendance, and treatment status as predictive variables of Geometry achievement. Finally, Model 5 dropped treatment status, leaving the only two statistically significant predictive variables in the study: attendance and prior achievement. The dependent variable in all of the models was student performance on the 2017 administration of the Geometry PARCC exam. The sample consisted of 225 students.

Table 49: Full Cohorts Model Summary (Geometry)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.332[a]	.110	.086	30.592	.110	4.504	6	218	.000
2	.328[b]	.107	.087	30.570	-.003	.691	1	218	.407
3	.325[c]	.105	.089	30.536	-.002	.518	1	219	.472
4	.318[d]	.101	.089	30.544	-.005	1.111	1	220	.293
5	.312[e]	.097	.089	30.537	-.004	.890	1	221	.346

a. Predictors: (Constant), BlackHispanicDummy, SexDummy, TreatmentStatus, Attendance, PriorAchievement, EconDisadDummy

b. Predictors: (Constant), SexDummy, TreatmentStatus, Attendance, PriorAchievement, EconDisadDummy

c. Predictors: (Constant), SexDummy, TreatmentStatus, Attendance, PriorAchievement

d. Predictors: (Constant), TreatmentStatus, Attendance, PriorAchievement

e. Predictors: (Constant), Attendance, PriorAchievement

Model 1, using all six independent variables of race, gender, socioeconomic status, attendance, prior achievement, and treatment status, was a statistically significant predictive model for the dependent variable: performance on the 2017 administration of the Geometry

PARCC exam, F-change$_{(6,218)}$ = 4.504, $p < .001$. An R^2 value of .11 indicates that 11% of variance in student performance on the Geometry PARCC exam can be explained by the six independent variables included. Model 2 retained all six variables from the first model with the exception of race, as it had the least significant predictive value in Model 1 based on p. An R^2 change of -.003 was identified. However, his change was found to be non-significant ($p = .407$). The resultant R^2 of .107 indicates that 10.7% of the variance in Geometry PARCC scores can be explained by the five variables included in this model. Model 3 continued the removal of non-significant variables by dropping socioeconomic status, but retaining gender, treatment status, attendance, and prior achievement. Again, a non-significant ($p = .472$) reduction in R^2 was identified. This reduction of .002 left an R^2 of .105, which indicates that 10.5% of the variance in Geometry performance can be explained by the four variables included in the model. Model 4 removed gender as an explanatory variable based on its non-significant status in Model 3, leaving treatment status, attendance, and prior achievement as independent variables. A non-significant ($p = .293$) R^2 change of .005 left an R^2 value of .101, meaning 10.1% of variance in scores on the 2017 Geometry PARCC exam can be explained by the three variables included in the model. Finally, Model 5 removed treatment status as an explanatory variable of Geometry performance due to its non-significant status in all prior models. The model was left with two significant predictive variables of Geometry achievement: attendance and prior achievement. This model had an R^2 of .097, indicating that 9.7% of the variance in Geometry performance can be explained by attendance and prior achievement. Although it has a smaller R^2 than the other models, the R^2 change was found to be non-significant, and this last model includes only significant independent variables.

An ANOVA analysis indicated that all five models were statistically significant predictors of performance on the 2017 Geometry PARCC exam. Model 1, $F_{(6,218)} = 4.504$, $p < .001$; Model 2, $F_{(5, 219)} = 5.274$, $p < .001$; Model 3, $F_{(4,220)} = 6.477$, $p < .001$; Model 4, $F_{(3,221)} = 8.262$, $p < .001$; and Model 5, $F_{(2,222)} = 11.954$, $p < .001$, are statistically significant. Model 5 is the only model that did not include any non-significant variables.

Table 50: Full Cohorts Coefficients (Geometry)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	589.908	51.282		11.503	.000		
	Attendance	-.376	.133	-.189	-2.835	.005	.918	1.089
	EconDisadDummy	4.538	4.919	.063	.922	.357	.879	1.138
	SexDummy	-4.009	4.113	-.063	-.975	.331	.989	1.011
	TreatmentStatus	-4.331	4.196	-.068	-1.032	.303	.945	1.058
	PriorAchievement	.212	.067	.213	3.154	.002	.899	1.112
	BlackHispanicDummy	-4.160	5.002	-.058	-.832	.407	.833	1.201
2	(Constant)	583.598	50.682		11.515	.000		
	Attendance	-.395	.130	-.199	-3.030	.003	.947	1.056
	EconDisadDummy	3.398	4.721	.047	.720	.472	.953	1.049
	SexDummy	-4.111	4.109	-.064	-1.001	.318	.990	1.010
	TreatmentStatus	-3.894	4.160	-.061	-.936	.350	.961	1.041
	PriorAchievement	.219	.066	.220	3.294	.001	.915	1.093
3	(Constant)	591.205	49.513		11.940	.000		
	Attendance	-.401	.130	-.202	-3.082	.002	.951	1.052
	SexDummy	-4.315	4.094	-.067	-1.054	.293	.995	1.005
	TreatmentStatus	-4.176	4.137	-.065	-1.009	.314	.969	1.032
	PriorAchievement	.211	.065	.211	3.221	.001	.945	1.059
4	(Constant)	587.653	49.410		11.893	.000		
	Attendance	-.400	.130	-.201	-3.078	.002	.951	1.052

		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
	TreatmentStatus	-3.896	4.129	-.061	-.943	.346	.973	1.028
	PriorAchievement	.212	.065	.213	3.250	.001	.945	1.058
5	(Constant)	591.076	49.265		11.998	.000		
	Attendance	-.389	.129	-.196	-3.007	.003	.958	1.043
	PriorAchievement	.205	.065	.206	3.162	.002	.958	1.043

a. Dependent Variable: GeometryAchievement

In Model 1, economically disadvantaged status ($p = .357$), gender ($p = .331$), treatment status ($p = .303$), and race ($p = .407$) were all found to be non-significant factors in predicting performance on the Geometry PARCC exam. Prior achievement ($B = .213$, $t = 3.154$, $p = .002$) and attendance ($B = -.189$, $t = -2.835$, $p = .005$) were statistically significant predictors of Geometry achievement. The positive value of B associated with prior achievement indicates that higher scores on previous math assessments are linked to higher scores on the Geometry PARCC Assessment. The negative B associated with attendance indicates the more students are absent, the more their performance on the Geometry PARCC exam decreases. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for each variable (Field, 2013): $VIF_{Attendance} = 1.089$, $VIF_{EconDisadDummy} = 1.138$, $VIF_{SexDummy} = 1.011$, $VIF_{TreatmentStatus} = 1.058$, $VIF_{PriorAchievement} = 1.112$, and $VIF_{BlackHispanicDummy} = 1.201$.

In Model 2, race was excluded as a predictive variable of Geometry performance due to its non-significant status in Model 1. The resultant model included three non-significant variables: socioeconomic status ($p = .472$), gender ($p = .318$), and treatment status ($p = .350$). Attendance ($B = -.199$, $t = -3.030$, $p = .003$) and prior achievement ($B = .220$, $t = 3.294$, $p = .001$) continued to be significant predictors of Geometry achievement. The effects of attendance and prior achievement with regard to predicting Geometry achievement were consistent with

Model 1. More days absent were associated with lower performance, and higher prior achievement was associated with higher performance on the 2017 Geometry PARCC exam. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for each variable (Field, 2013): $VIF_{Attendance}$ = 1.056, $VIF_{EconDisadDummy}$ = 1.054, $VIF_{SexDummy}$ = 1.010, $VIF_{TreatmentStatus}$ = 1.041, and $VIF_{PriorAchievement}$ = 1.093.

Model 3 continued to drop non-significant variables by excluding socioeconomic status from those included in Model 2. Gender (p = .293) and treatment status (p = .314) continued to be non-significant factors in predicting Geometry performance. Attendance (B = -.202, t = -3.082, p = .002) and prior achievement (B = .211, t = 3.294, p = .001) remained significant predictive variables for performance on the Geometry PARCC exam. The directionality of these variables was consistent with previous models. An increase in days absent was associated with a decrease in performance on the Geometry PARCC, and a better score on prior math assessments predicted better performance in Geometry. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for each variable (Field, 2013): $VIF_{Attendance}$ = 1.052, $VIF_{SexDummy}$ = 1.005, $VIF_{TreatmentStatus}$ = 1.032, and $VIF_{PriorAchievement}$ = 1.059.

Model 4 retained all dependent variables from Model 3 with the exception of gender, which was found to be non-significant. Treatment status continued to be a non-significant predictor of performance in Geometry (p = .346). Attendance (B = -.201, t = -3.078, p = .002) and prior achievement (B = .213, t = 3.250, p = .001) both continued to be significant predictors of performance on the Geometry PARCC exam. The negative B-value associated with attendance indicated that as the number of days absent increased, performance on the Geometry assessment decreased. The positive value associated with prior achievement indicated that a higher score on the previous math assessment was associated with higher scores on the Geometry PARCC exam. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for each variable (Field, 2013): $VIF_{Attendance} = 1.052$, $VIF_{TreatmentStatus} = 1.028$, and $VIF_{PriorAchievement} = 1.058$.

Finally, Model 5 dropped the last non-significant variable from previous models, treatment status, leaving only the significant predictive variables for Geometry performance: attendance ($B = -.196$, $t = -3.007$, $p = .003$) and prior achievement ($B = .206$, $t = 3.162$, $p = .002$). Attendance accounted for 3.8% of the overall variance of the model. Prior achievement accounted for 4.2% of the overall variance of the model, indicating that it is the strongest contributor. Consistent with previous models, more days absent was associated with lower performance in Geometry, and higher prior achievement was associated with higher performance in Geometry. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for variable, (Field, 2013): $VIF_{Attendance} = 1.043$ and $VIF_{PriorAchievement} = 1.043$.

Economically Disadvantaged Analyses

In order to answer the first sub-question dealing with Geometry performance (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Geometry PARCC end-of-course assessment?), an analysis was done on all T_1 and T_0 students who were identified as economically disadvantaged based on their enrollment in the free and reduced lunch program. The methodology from the first sub-question was replicated, with the exception the economically disadvantaged status being used as a dependent variable to identify the sample. Descriptive statistics were developed for both the T_1 and T_0 economically disadvantaged cohorts in order to create a profile of each.

Table 51: Economically Disadvantaged T_1 Descriptive Statistics (Geometry)

T1 Economically Disadvantaged Statistics

GeometryAchievement

N	Valid	24
	Missing	0
Mean		734.96
Median		735.00
Mode		736[a]
Std. Deviation		33.579
Variance		1127.520
Range		122
Minimum		680
Maximum		802

a. Multiple modes exist. The smallest value is shown

There were 24 students in the T_1 cohort who met the requirements for being included in the study and were identified as economically disadvantaged through their enrollment in the free and reduced lunch program. The mean score on the 2017 Geometry PARCC exam for this group of students was 734.96 with a standard deviation of 33.579. The median score for this group of students was 735. The scores ranged across 122 points, with the lowest being 680 (one student) and the highest being 802 (one student).

Table 52: Economically Disadvantaged T_0 Descriptive Statistics (Geometry)

T0 Economically Disadvantaged Statistics

GeometryAchievement

N	Valid	36
	Missing	0
Mean		746.92
Median		739.50
Mode		705[a]
Std. Deviation		37.183
Variance		1382.593
Range		151
Minimum		697
Maximum		848

a. Multiple modes exist. The smallest value is shown

There were 36 students who qualified for the study and were identified as economically disadvantaged based on their enrollment in the free and reduced lunch program. The mean score on the 2017 administration of the Geometry PARCC exam for these students was 746.92 with a standard deviation of 37.183. The scores ranged across 151 points, with the highest being 848 (one student) and the lowest being 697 (one student).

The sample size of n = 60 included in the analysis of this sub-question does not meet Field's (2013) threshold of 104 + k, where k is the number of variables included in the study. Since there are five variables included in the regression analysis, a minimum of n = 109 should be met for statistical significance. The following analysis and conclusions drawn from the analysis should be considered based on an understanding that the minimum sample size established by Field has not been met.

Table 53: Economically Disadvantaged Group Statistics (Geometry)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
GeometryAchievement	1	24	734.96	33.579	6.854
	0	36	746.92	37.183	6.197

Table 54: Economically Disadvantaged Independent Sample T-Test (Geometry)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GeometryAchievement	Equal variances assumed	.435	.512	-1.268	58	.210	-11.958	9.433	-30.841	6.925
	Equal variances not assumed			-1.294	52.791	.201	-11.958	9.240	-30.494	6.577

A preliminary comparative means test was run on the two cohorts in order to determine whether a difference existed in the students' average performance on the Geometry PARCC exam. An independent sample t-test revealed that there was no statistically significant difference in performance on the 2017 Geometry PARCC exam between economically disadvantaged students who took Algebra in the eighth grade and economically disadvantaged students who took Algebra in the ninth grade ($p = .210$).

After an initial independent sample t-test indicated that no significant difference existed between economically disadvantaged students in T_1 and T_0, a more robust, hierarchical regression was run to identify other factors that may contribute to performance in Geometry. An initial model was run and included all five variables in the study other than economically disadvantaged status. Subsequent models excluded one non-significant variable at a time in order of p-value with the exception of treatment status, until this was the only remaining non-significant variable. The final model included only significant variables that predict the Geometry performance of economically disadvantaged students.

Table 55: Economically Disadvantaged Variables (Geometry)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, TreatmentStatus, SexDummy, BlackHispanicDummy, PriorAchievement[b]	.	Enter
2	.[b]	SexDummy[c]	Remove
3	.[b]	BlackHispanicDummy[c]	Remove
4	.[b]	PriorAchievement[c]	Remove
5	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: GeometryAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, five models were estimated. Model 1 included all five variables in the study, other than economically disadvantaged status: race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), sex (dummy coded: 1 = female, 0 = male), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the "algebra for all" policy, 0 = member of T_0 cohort that was not affected by the "algebra for all" policy), attendance, and prior math achievement. In Model 2, gender was removed, leaving attendance, treatment status, race, and prior achievement as predictive variables for Geometry achievement. Model 3 removed race from the list of variables included in Model 2. Model 4 excluded prior achievement, leaving only treatment status and attendance. Finally, Model 5 removed treatment status, leaving only attendance as a predictive variable for Geometry performance.

Table 56: Economically Disadvantaged Model Summary (Geometry)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.358[a]	.128	.047	35.116	.128	1.588	5	54	.179
2	.355[b]	.126	.063	34.834	-.002	.120	1	54	.730
3	.349[c]	.121	.074	34.616	-.005	.302	1	55	.585
4	.315[d]	.099	.068	34.742	-.022	1.414	1	56	.239
5	.232[e]	.054	.038	35.298	-.045	2.870	1	57	.096

a. Predictors: (Constant), Attendance, TreatmentStatus, SexDummy, BlackHispanicDummy, PriorAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, BlackHispanicDummy, PriorAchievement

c. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), Attendance, TreatmentStatus

e. Predictors: (Constant), Attendance

The first model, including all five variables, did not result in a significant R^2 (p = .179). Furthermore, no subsequent model resulted in a significant R^2 – Model 2 (p = .730), Model 3 (p = .585), Model 4 (p = .239) and Model 5 (p = .096) – indicating that no model included in the study was statistically significant in predicting student performance on the Geometry PARCC exam.

The outcome of an ANOVA analysis on the models corroborates the conclusions from the model summary. None of the models is statistically significant in predicting student performance on the Geometry PARCC exam: Model 1 (p = .179), Model 2 (p = .109), Model 3 (p = .062), Model 4 (p = .051), and Model 5 (p = .074). Since no model was found to be statistically significant, none of the variables included in the study can be used as predictors for economically disadvantaged student's performance in Geometry.

Black and Hispanic Analyses

In order to answer the second sub-question dealing with performance in Geometry (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?), an analysis was run on all T_1 and T_0 students who identified themselves as black or Hispanic when enrolling in the district. The same methodology was used to identify which, if any, variables affected this subgroup's performance on the Geometry PARCC exam. In order to develop a profile of each cohort, descriptive statistics were run for each group.

Table 57: Black and Hispanic T_1 Descriptive Statistics (Geometry)

T1 Black and Hispanic Statistics

GeometryAchievement

N	Valid	21
	Missing	0
Mean		743.90
Median		740.00
Mode		693[a]
Std. Deviation		36.396
Variance		1324.690
Range		126
Minimum		691
Maximum		817

a. Multiple modes exist. The smallest value is shown

There were 21 students in the T_1 cohort of black and Hispanic students who met the requirements to be in the study. The mean score on the 2017 Geometry PARCC exam for these students was 743.9 with a standard deviation of 36.396. The median score for this cohort was 740. The scores' range was 126 points, with the lowest being 691 (one student) and the highest being 817 (one student).

Table 58: Black and Hispanic T_0 Descriptive Statistics (Geometry)

T0 Black and Hispanic

Statistics

GeometryAchievement

N	Valid	41
	Missing	0
Mean		730.61
Median		725.00
Mode		705[a]
Std. Deviation		27.986
Variance		783.244
Range		111
Minimum		691
Maximum		802

a. Multiple modes exist. The smallest value is shown

There were 41 black and Hispanic students in T_0 who met the requirements to be included in this portion of the study. The mean score on the 2017 Geometry PARCC exam for these students was 730.61 with a standard deviation of 27.986. The median score for this cohort was 725. The scores' range was 111 points, ranging from 691 (one student) to 802 (one student).

The sample size of n = 62 included in the analysis of this sub-question does not meet Field's (2013) threshold of 104 + k, where k is the number of variables included in the study. Since there are five variables in the regression analysis, a minimum of n = 109 should be met for statistical significance. The following analysis and conclusions drawn from the analysis should be considered based on an understanding that the minimum sample size established by Field has not been met.

Table 59: Black and Hispanic Group Statistics (Geometry)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
GeometryAchievement	1	21	743.90	36.396	7.942
	0	41	730.61	27.986	4.371

Table 60: Black and Hispanic Independent Sample T-Test (Geometry)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GeometryAchievement	Equal variances assumed	1.999	.163	1.596	60	.116	13.295	8.331	-3.368	29.958
	Equal variances not assumed			1.467	32.460	.152	13.295	9.066	-5.161	31.751

A preliminary comparative means test was run on the two cohorts to determine whether a difference in achievement existed. An independent sample t-test was conducted to compare the achievement of black and Hispanic students taking Algebra 1 in the eighth grade (T_1) against those taking it in the ninth grade (T_0). The results of the independent sample t-test indicate that there is not a statistically significant difference between the means of these two groups (p = .116).

After an initial, independent sample t-test indicated no difference in the average performance on the Geometry PARCC by black and Hispanic students in different cohorts, a hierarchical regression analysis was performed to determine whether the policy had an effect when the exogenous variables other than race that have been found to affect math performance were controlled for. These variables were socioeconomic status, gender, attendance, and prior math achievement. The initial model included all five variables with the exception of race, which was used to identify the sample in this portion of the study. Subsequent models removed variables that were identified as having no statistically significant impact on achievement in Geometry. Variables, other than the treatment variable, were removed individually starting with the largest p-value above .05 until only significant variables remained.

Table 61: Black and Hispanic Variables (Geometry)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement[b]	.	Enter
2	.[b]	Attendance[c]	Remove
3	.[b]	SexDummy[c]	Remove
4	.[b]	EconDisadDummy[c]	Remove
5	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: GeometryAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, five models were estimated. Model 1 included all demographic variables in the study other than race, which was used to identify the sample for this portion. The variables included attendance measured as the number of days a student missed school, treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the “algebra for all” policy, 0 = member of the T_0 cohort that was not affected by the “algebra for all” policy), sex (dummy coded: 1 = female, 0 = male), prior math achievement measured by performance on the Math 7 PARCC assessment, and socioeconomic status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged). In Model 2, the attendance variable was removed as it was determined to be non-significant in predicting students' performance on the Geometry PARCC exam, and it had the highest p-value of all the variables tested in Model 1. In Model 3, the gender variable was removed from the remaining four variables as it had the highest p-value in Model 2. In Model 4, socioeconomic status was removed as it was found to be non-significant and was the only non-significant factor left other than treatment status. Finally, treatment status was removed due to its non-significant predictive value, leaving only prior achievement as a predictor of Geometry PARCC performance. The dependent variable in all models was performance on the 2017 Geometry PARCC Assessment. The sample size was 62 students.

Table 62: Black and Hispanic Model Summary (Geometry)

Model Summary

					Change Statistics				
Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.374[a]	.140	.063	30.425	.140	1.823	5	56	.123

2	.370[b]	.137	.077	30.207	-.003	.184	1	56	.670
3	.366[c]	.134	.089	30.006	-.004	.232	1	57	.632
4	.360[d]	.130	.100	29.822	-.004	.277	1	58	.601
5	.272[e]	.074	.059	30.497	-.055	3.749	1	59	.058

a. Predictors: (Constant), Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement

b. Predictors: (Constant), EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement

c. Predictors: (Constant), EconDisadDummy, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), TreatmentStatus, PriorAchievement

e. Predictors: (Constant), PriorAchievement

The first model, including all five variables, did not result in a significant R^2 ($p = .123$). Furthermore, no subsequent model resulted in a significant R^2 change: Model 2 ($p = .67$), Model 3 ($p = .632$), Model 4 ($p = .601$), and Model 5 ($p = .058$). This indicates that no model included in the study is statistically significant in improving the predictive power of previous models with regard to the Geometry PARCC exam.

An ANOVA analysis indicated that although no model resulted in a statistically significant F-change compared to the model immediately prior, the final three models were statistically significant as predictors of Geometry PARCC performance. Model 3, $F_{(3,58)} = 2.983$, $p = .039$; Model 4, $F_{(2,59)} = 4.39$, $p = .017$; and Model 5, $F_{(1,61)} = 4.811$, $p = .032$, were statistically significant. Model 5 is the only model that did not include any non-significant predictor variables.

Table 63: Black and Hispanic Coefficients (Geometry)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
3	(Constant)	488.925	97.379		5.021	.000		
	TreatmentStatus	15.181	8.146	.230	1.864	.067	.977	1.024
	EconDisadDummy	4.195	7.968	.067	.526	.601	.916	1.092

	PriorAchievement	.322	.129	.318	2.491	.016	.918	1.090
4	(Constant)	504.134	92.424		5.455	.000		
	TreatmentStatus	15.600	8.057	.237	1.936	.058	.986	1.014
	PriorAchievement	.304	.124	.300	2.454	.017	.986	1.014
5	(Constant)	530.187	93.510		5.670	.000		
	PriorAchievement	.276	.126	.272	2.193	.032	1.000	1.000

a. Dependent Variable: GeometryAchievement

In Model 3, treatment status (p = .067) and socioeconomic status (p = .601) were both found to be non-significant factors of achievement on the Geometry PARCC exam by black and Hispanic students. Prior achievement (B = .318, t = 2.491, p = .016) was found to be a statistically significant factor in predicting black and Hispanic students' performance on the assessment. This positive B-value indicates that black and Hispanic students with higher prior achievement scores perform better on the Geometry PARCC than their lower-scoring counterparts. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.024$, $VIF_{EconDisadDummy} = 1.092$, and $VIF_{PriorAchievement} = 1.090$.

In Model 4, treatment status continued to be a non-significant predictive variable (p = .058). Prior achievement continued to be significant (B = .3, t = 2.454, p = .017) in predicting black and Hispanic students' performance on the Geometry PARCC Assessment. Again, the positive B indicates that higher prior achievement predicts higher performance in Geometry in this subset of students. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.014$ and $VIF_{PriorAchievement} = 1.014$.

In Model 4, one variable was tested, prior achievement, and it was found to be a statistically significant predictor of Geometry PARCC performance for black and Hispanic students (B = .272, t = 2.193, p = .032). Race accounted for 7.4% of the overall variance of the model. Again, the positive B indicates that higher scores on the prior achievement variable are associated with higher performance on the Geometry PARCC for these students. Multicollinearity statistics do not need to be considered for this model as only one variable was included.

Female Analyses

In order to answer the third sub-question dealing with performance in Geometry (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performances on the Geometry PARCC end-of-course assessment?), an analysis was run on all T_1 and T_0 students who identified themselves as female when they registered for school in the district. The same application of a hierarchical regression was used to identify which variables in the study, if any, had a statistically significant impact on female performance on the Geometry PARCC. For the development of a profile for each cohort, descriptive statistics were run on each group.

Table 64: Female T_1 Descriptive Statistics (Geometry)

T1 Female Statistics

GeometryAchievement

N	Valid	47
	Missing	0
Mean		741.09
Std. Error of Mean		4.522

Median	742.00
Mode	748
Std. Deviation	31.003
Range	121
Minimum	681
Maximum	802

There were 47 female students in the T_1 cohort who met the requirements to be included in the study. The mean score on the 2017 administration of the Geometry PARCC Assessment for these students was 741.09 with a standard deviation of 31.003. The median score for this group was 742. The scores' range was 121 points with the lowest being 681 (one student) and the highest being 802 (one student).

Table 65: Female T_0 Descriptive Statistics (Geometry)

T0 Female Statistics

GeometryAchievement

N	Valid	57
	Missing	0
Mean		736.47
Std. Error of Mean		4.324
Median		731.00
Mode		705[a]
Std. Deviation		32.649
Range		165
Minimum		680
Maximum		845

a. Multiple modes exist. The smallest value is shown

There were 57 female students in the T_0 cohort who met the requirements to be included in the study. The mean score for this group was 736.47 with a standard deviation of 32.649. The median score for this group was 731. Scores for this group ranged across165 points, with the lowest being 680 (one student) and the highest being 854 (one student).

The sample size of n = 104 included in the analysis of this sub-question does not meet Field's (2013) threshold of 104 + k, where k is the number of variables included in the study. Since there are five variables in the regression analysis, a minimum of n = 109 should be met for statistical significance. The following analysis and conclusions drawn from the analysis should be considered based on an understanding that the minimum sample size established by Field has not been met.

Table 66: Female Group Statistics (Geometry)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
GeometryAchievement	1	47	741.09	31.003	4.522
	0	57	736.47	32.649	4.324

Table 67: Female Independent Sample T-Test (Geometry)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GeometryAchievement	Equal variances assumed	.039	.845	.733	102	.465	4.611	6.289	-7.862	17.085
	Equal variances not assumed			.737	99.943	.463	4.611	6.257	-7.803	17.026

A preliminary comparative means test was run on the female students in the two cohorts to determine whether there was a difference in average performance. An independent sample t-test was conducted to compare the scores of female students who took Algebra in the eighth grade (T_1) against those who took Algebra in ninth grade (T_0). The results of the independent sample t-test indicate that there is no statistically significant difference in performance between these two groups ($p = .465$).

After the preliminary independent sample t-test indicated there was no difference in the performance on the Geometry PARCC of female students who took Algebra in the eighth grade and those who took Algebra in the ninth grade, a more sophisticated hierarchal regression was run to determine whether the Algebra in eighth grade policy had an effect when exogenous variables, other than gender, that have been found to affect math performance were controlled for. These exogenous variables include socioeconomic status, race, attendance, and prior math achievement. The initial model included all five variables (the exogenous variables, excluding gender, and treatment status). Subsequent models removed variables one at a time if they were found to be insignificant in order of significance. Variables other than the treatment variable were removed individually by the highest p-value above .05 until only significant variables remained.

Table 68: Female Variables (Geometry)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy[b]	.	Enter
2	.[b]	BlackHispanicDummy[c]	Remove

3	.[b]	EconDisadDummy[c]	Remove
4	.[b]	Attendance[c]	Remove
5	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: GeometryAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, five models were estimated. Model 1 included all five of the potentially significant predictive variables for Geometry performance, other than gender, that were included in this study: attendance measured as the number of days a student missed school, treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the "algebra for all" policy, 0 = member of the T_0 cohort that was not affected by the "algebra for all" policy), race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), prior math achievement measured by student performance on the Math 7 PARCC assessment, and socioeconomic status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged). In Model 2, the race variable was removed as it had the highest p-value over .05 that was not associated with treatment status when Model 1 was run. This left attendance, treatment status, economically disadvantaged status, and prior achievement as predictive variables for Geometry performance. Model 3 continued with the methodology to drop variables, excluding socioeconomic status and leaving attendance, treatment status, and prior achievement as predictive variables for Geometry performance. Model 4 dropped attendance from the variables included in Model 3, leaving just treatment status and prior achievement as predictors for Geometry achievement. Finally, Model 5 retained only prior achievement as it was found to be the only significant variable in any of the models that predict achievement in Geometry. The dependent variable in all five models was achievement in Geometry measured by performance on the 2017 Geometry PARCC Assessment. The sample size consists of 104 students.

Table 69: Female Model Summary (Geometry)

Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	Change Statistics				
					R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.359[a]	.129	.085	30.469	.129	2.903	5	98	.017
2	.346[b]	.120	.084	30.473	-.009	1.022	1	98	.314
3	.322[c]	.104	.077	30.596	-.016	1.812	1	99	.181
4	.271[d]	.074	.055	30.953	-.030	3.372	1	100	.069
5	.268[e]	.072	.063	30.830	-.002	.186	1	101	.667

a. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

c. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), TreatmentStatus, PriorAchievement

e. Predictors: (Constant), PriorAchievement

Model 1, using all five variables other than gender as independent predictive variables for performance in Geometry, was found to be statistically significant, F-change$_{(5,98)}$ = 2.903, p = .017. An R^2 value of .129 indicates that 12.9% of the variance in scores on the 2017 Geometry PARCC can be explained by the five variables included. Model 2 retained all of the variables included in Model 1 other than race. As would be expected when any variable is excluded, the R^2 value dropped. However, this change was found to be non-significant, F-change$_{(1,98)}$ = 1.022, p = .314, indicating that the removal of race did not have a statistically significant effect on the model's predictive power. Model 3 dropped the socioeconomic status variable from Model 2, leaving attendance, treatment status, and prior achievement as predictors for Geometry performance. Again, this resulted in a reduction in R^2. However, this change was found not to be statistically significant, F-change$_{(1,99)}$ = 1.812, p = .181, indicating that the removal of socioeconomic status did not have a statistically significant impact on the model's ability to predict achievement in Geometry. Model 4 retained Model 3's independent variables with the exception of attendance. Once again the reduction in R^2 that was associated with the exclusion of this variable was found to be non-significant, F-change$_{(1,100)}$ = 3.372, p = .069. Finally, Model 5 retained only prior achievement as a predictive variable. No significant change was identified when treatment status was excluded as a predictor, F-change$_{(1,101)}$ = .186, p = .667. The R^2 associated with Model 5 of .072 indicates that 7.2% of the variance in scores on the Geometry PARCC Assessment can be explained by the independent variable, prior achievement. This was the only model that did not include any non-significant predictor variables.

An ANOVA analysis indicated that all five models were statistically significant in predicting Geometry performance. Model 1, $F_{(5,98)}$ = 2.903, p = .017; Model 2, $F_{(4,99)}$ = 3.372, p = .012; Model 3, $F_{(3,100)}$ = 3.861, p = .012; Model 4, $F_{(2,101)}$ = 4.011, p = .021; and Model 5, $F_{(1,102)}$ = 7.899, p = .006, are statistically significant.

Table 70: Female Coefficients (Geometry)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	601.389	76.714		7.839	.000		
	TreatmentStatus	1.869	6.099	.029	.306	.760	.969	1.032
	BlackHispanicDummy	-7.541	7.459	-.108	-1.011	.314	.782	1.279
	EconDisadDummy	12.310	7.639	.166	1.612	.110	.838	1.194
	PriorAchievement	.187	.100	.197	1.871	.064	.805	1.242
	Attendance	-.435	.224	-.195	-1.938	.055	.875	1.143
2	(Constant)	579.927	73.727		7.866	.000		

	TreatmentStatus	2.169	6.092	.034	.356	.723	.971	1.030
	EconDisadDummy	9.660	7.176	.130	1.346	.181	.950	1.053
	PriorAchievement	.213	.097	.224	2.210	.029	.864	1.158
	Attendance	-.436	.224	-.196	-1.945	.055	.875	1.143
3	(Constant)	596.981	72.924		8.186	.000		
	TreatmentStatus	1.550	6.100	.024	.254	.800	.977	1.024
	PriorAchievement	.194	.096	.204	2.023	.046	.884	1.131
	Attendance	-.412	.225	-.185	-1.836	.069	.881	1.135
4	(Constant)	548.872	68.851		7.972	.000		
	TreatmentStatus	2.651	6.141	.042	.432	.667	.986	1.014
	PriorAchievement	.251	.092	.263	2.730	.007	.986	1.014
5	(Constant)	546.584	68.372		7.994	.000		
	PriorAchievement	.255	.091	.268	2.811	.006	1.000	1.000

a. Dependent Variable: GeometryAchievement

In Model 1, no variables were found to be statistically significant predictors of females' performance on the Geometry PARCC exam: treatments status ($p = .760$), race ($p = .314$), socioeconomic status ($p = .110$), prior achievement ($p = .064$), and attendance ($p = .055$). There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $\text{VIF}_{\text{TreatmentStatus}} = 1.032$, $\text{VIF}_{\text{BlackHispanicDummy}} = 1.279$, $\text{VIF}_{\text{EconDisadDummy}} = 1.794$, $\text{VIF}_{\text{PriorAchievement}} = 1.242$, and $\text{VIF}_{\text{Attendance}} = 1.143$.

The removal of race in Model 2 did increase the effect of prior achievement in predicting females' outcomes in Geometry ($B = .224$, $t = 2.210$, $p = .029$). The positive B-value associated with prior achievement indicates that higher prior achievement in math is associated with a better performance in Geometry by females. All other variables in this model remained non-significant: treatment status ($p = .723$), socioeconomic status ($p = .181$), and attendance ($p = .055$). There are no concerns regarding collinearity or multicollinearity as VIF do not exceed two for any variable

(Field, 2013): $VIF_{TreatmentStatus}$ = 1.030, $VIF_{EconDisadDummy}$ = 1.053, $VIF_{PriorAchievement}$ = 1.158, and $VIF_{Attendance}$ = 1.143.

In Model 3, when socioeconomic status was removed as an independent variable, the results remained the same. Prior achievement was the only significant predictive variable (B = .204, t = 2.023, p = .046). The positive B-value continues to indicate that higher scores on the prior achievement assessment predict higher performance on the Geometry PARCC Assessment for female students. The other variables in the study remained non-significant in predicting outcomes in Geometry for girls: treatment status (p = .800) and attendance (p = .069). There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus}$ = 1.024, $VIF_{PriorAchievement}$ = 1.131, and $VIF_{Attendance}$ = 1.135.

Model 4 dropped attendance as its p-value was the highest non-significant value other than treatment status, leaving only prior achievement and treatment status. Treatment status remained non-significant (p = .667). Higher prior achievement continued to be a predictor of higher performance on the Geometry PARCC by females (B = .263, t = 2.730, p = .007). There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus}$ = 1.014 and $VIF_{PriorAchievement}$ = 1.014.

Finally, Model 5 included the only significant variable for predicting female students' Geometry PARCC scores : prior achievement. Scores on the prior achievement assessment continued to have a positive correlation with performance on the Geometry PARCC exam by female students (B = .268, t = 2.811, p = .006). Prior achievement accounted for 7.2% of the variance of the overall model. Collinearity need not be addressed as this model included only one variable.

Male Analyses

In response to the final research sub-question (How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard-eighth grade math course affect male students as measured by their performances on the Geometry PARCC end-of-course assessment?), an analysis was run on all eligible male members of cohort T_0, the students who took the traditional Algebra in the ninth-grade sequence, and the eligible male members of cohort T_1, who took Algebra in the eighth grade. Descriptive statistics were measured for both T_0 and T_1 in order to create a profile for each cohort.

Table 71: Male T_1 Descriptive Statistics (Geometry)

T1 Male Statistics

GeometryAchievement

N	Valid	63
	Missing	0
Mean		740.56
Median		744.00
Mode		736
Std. Deviation		31.517
Variance		993.315
Range		154
Minimum		663
Maximum		817

There were 63 male students in T_1 who met the requirements to be included in the study. The mean score on the 2017 Geometry PARCC for these students was a 740.56 with a standard deviation of 31.517. The median score for this group was 744. The scores ranged from 663 (one student) to 817 (one student).

Table 72: Male T_0 Descriptive Statistics (Geometry)

T0 Male Statistics

GeometryAchievement

N	Valid	58
	Missing	0
Mean		746.09
Median		738.00
Mode		719[a]
Std. Deviation		32.749
Variance		1072.466
Range		152
Minimum		696
Maximum		848

a. Multiple modes exist. The smallest value is shown

There were 58 male students in T_0= who qualified for inclusion in the study. The mean score for these students on the 2017 Geometry PARCC was 746.09 with a standard deviation of 32.749. The median scores for these students was 738. The scores ranged across 152 points, from 696 (one student) to 848 (one student).

Table 73: Male Group Statistics (Geometry)

Group Statistics

	TreatmentStatus	N	Mean	Std. Deviation	Std. Error Mean
GeometryAchievement	1	63	740.56	31.517	3.971
	0	58	746.09	32.749	4.300

Table 74: Male Independent Sample T-Tests (Geometry)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GeometryAchievement	Equal variances assumed	.150	.699	-.946	119	.346	-5.531	5.844	-17.102	6.040
	Equal variances not assumed			-.945	117.265	.347	-5.531	5.853	-17.122	6.061

A preliminary comparative means test was run on the two cohorts to determine whether a difference in achievement existed between boys from T_1 and boys from T_0. The results of the independent sample t-test indicate that there is no statistical difference between the means of these two groups ($p = .346$).

After an initial independent sample t-test indicated no difference in the average male performance on the Geometry PARCC by those in different cohorts, a hierarchical regression analysis was performed to identify whether the policy had an effect on these groups of students when the other exogenous variables were controlled for. These variables have been demonstrated as affecting math performance: attendance, race, gender, and prior math achievement. An initial model was run that included all five variables (the four exogenous variables listed and treatments status). Subsequent models removed non-significant variables in order of p-value. The highest p-value above .05 other than treatment status was removed until only significant variables remained.

Table 75: Male Variables (Geometry)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy[b]	.	Enter
2	.[b]	EconDisadDummy[c]	Remove
3	.[b]	BlackHispanicDummy[c]	Remove
4	.[b]	TreatmentStatus[c]	Remove

a. Dependent Variable: GeometryAchievement.

b. All requested variables entered.

c. All requested variables removed.

In this hierarchical regression analysis, four models were estimated. Model 1 included all five of the potentially significant predictive variables for Geometry PARCC performance other than gender, which was used to identify the sample. The predictive variables included race (dummy coded: 1 = black or Hispanic, 0 = not black or Hispanic), economically disadvantaged status (dummy coded: 1 = economically disadvantaged, 0 = not economically disadvantaged), treatment status (dummy coded: 1 = member of T_1 cohort that was affected by the "algebra for all" in eighth grade policy, 0 = member of the T_0 cohort that took the traditional ninth grade algebra sequence), attendance, and prior math achievement. In Model 2, economically disadvantaged status was removed, based on its associated p-value, leaving race, treatment status, attendance, and prior achievement. Model 3 dropped race from Model 2 leaving treatment status, attendance, and prior achievement. Finally, Model 4 dropped the treatment status, leaving only attendance and prior achievement as predictive variables of Geometry PARCC performance by males. The dependent variable in all models was achievement in Geometry, as measured by student performance on the 16-17 Geometry PARCC Assessment. The sample size was 121 students.

Table 76: Male Model Summary (Geometry)

Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	Change Statistics				
					R-Square Change	F-Change	df1	df2	Sig. F-Change
1	.336[a]	.113	.074	30.882	.113	2.928	5	115	.016
2	.336[b]	.113	.082	30.750	.000	.008	1	115	.927
3	.333[c]	.111	.088	30.655	-.002	.284	1	116	.595
4	.302[d]	.091	.076	30.863	-.020	2.602	1	117	.109

a. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy

b. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), Attendance, PriorAchievement

Model 1 used all five independent variables, attendance, socioeconomic status, prior achievement, and treatment status. Model 1 was a statistically significant predictive model of the dependent variable: performance on the Geometry PARCC Assessment by males, F-change$_{(5,115)}$ = 2.928, p = .016. An R^2 value of .113 indicates that 11.3% of the variance in performance on the Geometry assessment by these students can be explained by the five variables included. Model 2 retained all of the variables from Model 1 with the exception of socioeconomic status due to its p-value. There was no measureable change in R^2, although it can be assumed that it dropped slightly since a variable was removed. This change, however, was non-significant, F-change$_{(1,115)}$ = .008, p = .927. The remaining R^2 of .113 indicates that 11.3% of variance in Geometry performance by males can be explained by the four variables included. Model 3 retained all variables from Model 2 except race, which was dropped as it had the highest p-value above .05. As expected with the removal of any variable, the R^2 dropped to .111, however this drop was found to be non-significant, F-change$_{(1,116)}$ = .284, p = .595. Three variables included in Model 3 can explain the 11.1%variance of Geometry scores. The final model, Model 4, retained only statistically significant predictor variables: attendance and prior achievement. The removal of treatment status resulted in a reduction in R^2 to .091. However, this was found to be non-significant, F-change$_{(1,117)}$ = 2.602, p = .109. The R^2 of .091 indicates that 9.1% of the variance in males' scores on the Geometry PARCC exam can be explained by the two variables in Model 4. Although it has a slightly smaller R^2 than prior models, Model 4 is the best model for predicting males' Geometry PARCC scores because it includes only significant variables, and the drop in R^2 associated with removing variables was found to be non-significant.

An ANOVA analysis indicated that all four models were statistically significant as predictors of male students' performance on the Geometry PARCC exam. Model 1, $F_{(5,115)}$ = 2.928, p = .016; Model 2, $F_{(4,116)}$ = 3.690.;Model 3 is statistically significant, $F_{(3,117)}$ = 4.855, p = .003. Model 4 is statistically significant, $F_{(2,118)}$ = 5.902, p = .004, and is the only model that did not include any non-significant predictor variables.

Table 77: Male Coefficients (Geometry)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	585.660	71.210		8.224	.000		
	TreatmentStatus	-9.856	5.862	-.154	-1.681	.095	.919	1.088
	BlackHispanicDummy	-3.433	6.988	-.047	-.491	.624	.830	1.205

	EconDisadDummy	-.607	6.587	-.009	-.092	.927	.884	1.132
	PriorAchievement	.223	.094	.216	2.377	.019	.938	1.066
	Attendance	-.381	.170	-.209	-2.245	.027	.893	1.119
2	(Constant)	584.444	69.678		8.388	.000		
	TreatmentStatus	-9.828	5.829	-.154	-1.686	.094	.922	1.085
	BlackHispanicDummy	-3.592	6.743	-.050	-.533	.595	.883	1.132
	PriorAchievement	.224	.092	.217	2.432	.017	.962	1.039
	Attendance	-.378	.166	-.207	-2.283	.024	.932	1.073
3	(Constant)	580.597	69.090		8.404	.000		
	TreatmentStatus	-9.142	5.668	-.143	-1.613	.109	.969	1.032
	PriorAchievement	.228	.092	.220	2.486	.014	.968	1.033
	Attendance	-.398	.161	-.218	-2.470	.015	.980	1.020
4	(Constant)	591.556	69.220		8.546	.000		
	PriorAchievement	.207	.091	.200	2.264	.025	.988	1.012
	Attendance	-.375	.161	-.205	-2.320	.022	.988	1.012

a. Dependent Variable: GeometryAchievement

In Model 1, neither of the demographic variables, race (p = .624) and socioeconomic status (p = .927), nor treatment status (p = .095) were found to be statistically significant in predicting males' performance on the Geometry PARCC Assessment. Prior achievement (B = .216, t = 2.377, p = .019) and attendance (B = -.209, t = -2.245, p = .027) were both found to be significant in predicting male students' performance in Geometry. The positive B-value associated with prior achievement indicates that higher prior achievement scores are associated with higher performance in Geometry, and vice versa. The negative B-value associated with attendance indicates that as absent days increase, performance on the Geometry PARCC decreases. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.088$, $VIF_{BlackHispanicDummy} = 1.205$, $VIF_{EconDisadDummy} = 1.132$, $VIF_{PriorAchievement} = 1.066$, and $VIF_{Attendance} = 1.119$.

In Model 2, socioeconomic status was excluded from the variables included in Model 1. Treatment status ($p = .094$) and race ($p = .595$) continued to be non-significant in predicting male students' performance on the Geometry PARCC Assessment. Consistent with Model 1, both prior achievement ($B = .217$, $t = 2.486$, $p = .017$) and attendance ($B = -.207$, $t = -2.283$, $p = .024$) were significant in predicting males' performance on the Geometry PARCC Assessment. The directionality was consistent as well, with a positive B-value for prior achievement indicating that higher prior achievement is associated with higher achievement in Geometry, and a negative B-value of attendance indicates that as absent days increase, performance in Geometry decreases. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.085$, $VIF_{BlackHispanicDummy} = 1.132$, $VIF_{PriorAchievement} = 1.039$, and $VIF_{Attendance} = 1.073$.

Model 3 removed race as a predictive variable as it was the only non-significant variable other than treatment status that was included in Model 2. The results remained consistent with previous models. Treatment status was found to be non-significant in predicting performance in Geometry ($p = .109$). Prior achievement ($B = .220$, $t = 2.486$, $p = .014$) was found to be a statistically significant predictor of males' performance in Geometry. The positive B indicates that increases in prior achievement are associated with increases in performance in Geometry by males. Attendance ($B = -.218$, $t = -2.470$, $p = .015$) was also found to be significant in predicting performance in Geometry. The negative B is consistent with previous findings: an increase in days absent is associated with a decrease in students' performance on the Geometry PARCC Assessment. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{TreatmentStatus} = 1.032$, $VIF_{PriorAchievement} = 1.033$, and $VIF_{Attendance} = 1.020$.

Finally, Model 4 removed treatment status as a predictor variable for males' performance in Geometry as it was the last non-significant variable that was included in Model 3. The remaining two variables, prior achievement ($B = .200$, $t = 2.264$, $p = .025$) and attendance ($B = -.205$, $t = -2.320$, $p = .022$), both remained significant in predicting Geometry outcomes for males. Prior achievement accounted for 4% of the variance of the overall model. Attendance accounted for 4.2% of the variance to the overall model, indicating that it is the strongest contributor. As in previous models, the positive B-value for prior achievement indicates that better performance on the prior achievement assessment is associated with better achievement on the Geometry PARCC by males and vice versa. Attendance was also consistent with regard to its directional effect. The negative B-value indicates that increasing days absent is associated with a decrease in males' performance on the Geometry PARCC Assessment. There are no concerns regarding collinearity or multicollinearity as the VIF do not exceed two for any variable (Field, 2013): $VIF_{PriorAchievement} = 1.012$, and $VIF_{Attendance} = 1.012$.

Summary of Findings

The purpose of this study was to identify which, if any, effects a universal Algebra in eighth grade policy has on present and future math performance. The research questions and sub-questions addressed both the full student body affected by the policy as well as subgroups that had been identified in the research to perform differently than the population based on specific demographic variables. The following tables summarize the findings and illustrate the standardized beta values for any significant variables in each subgroup:

*Table 78: 2015-2016 Algebra PARCC Performance Standardized Betas for Significant Variables**

	Full Cohorts	Economically Disadvantaged	Black or Hispanic	Females	Males
Treatment	-.143		.222		
Gender					
Race		.337			
Socioeconomic Status			.296	.217	
Prior Achievement	.193	.341	.421	.232	
Attendance	-.299	-.309	-.387	-.397	-.270

*Beta values reflect final models for each analysis

The isolated effect of the policy is represented in the treatment variable. The study found that the policy had a negative effect on mean Algebra PARCC performance for all students. However, that effect was not observed in any of the subgroups when isolated. Additionally, the policy actually had both positive and negative effects on the whole group when addressing black and Hispanic students only. That being said, prior achievement and attendance were both stronger predictive variables than treatment in both cases where treatment was statistically significant. In fact, attendance had a statistically significant effect on every group that was studied and in all cases. Higher absentee rates were associated with worse academic performance. Similarly, prior achievement had a statistically significant effect on every subgroup other than males, as a predictive variable for achievement on the Algebra PARCC assessment. Socioeconomic status could be used to predict achievement in black and Hispanic students as well as females. In both cases, being economically disadvantaged predicted worse performance on the Algebra PARCC assessment. Race only had an effect on those students who were economically disadvantaged. Students in this subgroup performed better on the PARCC if they identified as black or Hispanic than students who identified as other races. Finally, gender was not found to have any predictive value with regard to achievement in Algebra 1 in any case.

In order to further clarify the results of the Algebra 1 performance portion of the study, the following table illustrates the percent of variance and is explained by each significant factor included in the study:

*Table 79: 2015-2016 Algebra PARCC Performance Percent of Variance Explained by Variable**

	Full Cohorts	Economically Disadvantaged	Black or Hispanic	Females	Males
Treatment	2.04%		4.92%		
Gender					
Race		11.35%			
Socioeconomic Status			8.76%	4.71%	
Prior Achievement	3.72%	11.63%	17.72%	5.38%	
Attendance	8.94%	9.56%	14.98%	15.76%	7.29%

*Percent of variance explained by each variable reflects final models for each analysis

In order to determine the percent variance that is explained by each variable, the beta values displayed in the above table were squared. This table further illustrates that prior achievement and attendance are the strongest predictive variables included in the study. Treatment of the policy to move Algebra to the eighth grade explained 2.04% of the variance in scores for all students and 4.92% of scores by black or Hispanic students, but had no effect on the other subgroups.

Table 80: 2016-2017 Geometry PARCC Performance Standardized Betas for Significant Variables

	Full Cohorts	Economically Disadvantaged	Black or Hispanic	Females	Males
Treatment					
Gender					
Race					
Socioeconomic Status					
Prior Achievement	.206		.272	.268	.200
Attendance	-.196				-.205

*Beta values reflect final models for each analysis

With regard to future achievement, measured by students' performance on the Geometry PARCC Assessment, there was no statistically significant indication that the implementation of an Algebra in eighth grade policy had any effect on performance for the whole student body or any subgroup included in the study. In the case of Geometry, performance, gender, race, and socioeconomic status were also found to have no predictive value. Prior achievement remained a positively correlated predictor in all cases except for economically disadvantaged students. The directionality of the effect is unsurprising in that higher prior achievement predicts higher future achievement. Attendance was statistically significant in predicting performance by both the full student body and males when isolated. Interestingly, increased absenteeism was not associated with worse (or better) scores for economically disadvantaged, black or Hispanic, or female students. This is at odds with performance in Algebra, where absenteeism was statistically significant in predicting outcomes for all subgroups.

In order to further clarify the results of the Geometry performance portion of the study, the following table illustrates the percent of variance that is explained by each significant factor included in the study:

Table 81: 2016-2017 Geometry PARCC Performance Percent of Variance Explained by Variable

	Full Cohorts	Economically Disadvantaged	Black or Hispanic	Females	Males
Treatment					
Gender					
Race					
Socioeconomic Status					
Prior Achievement	4.24%		7.40%	7.18%	4.00%
Attendance	3.84%				4.20%

*Percent of variance explained by each variable reflects final models for each analysis

In the same process used for Algebra performance, the beta values from the final model of the regression analyses were squared to identify the percent of variance explained by each variable for each subgroup. Prior achievement had the largest effect on performance in

Geometry, in particular with black or Hispanic students and females, for which the variable explained over 7% of the variance in performance. Attendance explained around 4% of the variance in both the whole cohort and males, but did not have an effect on any of the other subgroups.

The results of the study indicate that the effect of the “algebra for all students in eighth grade policy” are minimal when predicting student performance in Algebra and non-existent when predicting student performance in Geometry. Prior achievement and attendance appear to be much more important in predicting math performance. Additionally, gender was found to have no effect on student performance in Algebra or Geometry in the context of this study. In isolated cases, race and socioeconomic status do play a role in student outcomes. However, in all cases where these variables did prove to be statistically significant, their effect was smaller than both prior achievement and attendance.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this study was to identify the effect of accelerating students through the K-12 math curriculum through the compulsory enrollment of students in Algebra 1 in the eighth grade. This study measured students' achievement in Algebra 1 and Geometry based on the end-of-year PARCC assessment in each subject. A hierarchical regression was used to identify the effect of the policy when other variables that have been identified as affecting performance in math included gender (Casad et al., 2015; Cheryan, 2012; Fryer & Levitt, 2010; Paglin & Rufolo, 1990), race (Harris & Herrington, 2006; Phillips et al., 1998; Shelly, 2009), socioeconomic status (Diaz, 2008; Sirin, 2005; White, 1982), attendance, and prior achievement were controlled for. This study sought to add to the existing body of research by demonstrating the effect of an Algebra 1 in eighth grade for all policy on the student body's academic performance as well as identifying the effect of this policy on subgroups including males, females, black and Hispanic students, and economically disadvantaged students. If the policy of accelerating all students into Algebra 1 in the eighth grade has a positive or no effect on student achievement, then the policy can be considered a success insofar as its goal is to allow students to access higher level (pre-calculus and above) math courses in high school without compromising the foundational skills learned in Algebra 1.

This chapter includes a discussion of each research question and how the policy has affected the achievement of the group of students in question on each assessment as well as a discussion of the strength of these effects and those of the other variables included. A summary of results for each subject (Algebra and Geometry) follow the research question discussions.

Additionally, this chapter includes recommendations for policy makers and future researchers given the results of the study.

Research Questions and Answers

Research questions one through five address the effect of the “algebra for all” in eighth grade policy on student achievement in Algebra.

Research Question 1: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect student achievement, measured by student performance on the Algebra 1 PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was run including all six independent variables in the study (treatment, gender, race, socioeconomic status, prior achievement, and attendance) and subsequently dropping those that were found to be non-significant. This left a final model with only those variables that had an effect on the dependent variable: performance on the Algebra 1 PARCC exam. The results of this analysis indicated that the adoption of the “algebra for all” in eighth grade policy had a negative effect on student performance:

Table 82: Reported Results for Research Question 1

	Treatment	Gender	Race	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values	-.143				.193	-.299
Percent of Variance Explained	2.04%				3.72%	8.94%

Gender, race, and socioeconomic status did not have any effect on students' performance on the Algebra 1 PARCC exam. Attendance was the strongest predictor, accounting for 8.94% of the variance in performance, and prior achievement also explained 3.72% of the variance.

Although students who took Algebra in the eighth grade did see a decrease in their performance on the Algebra 1 PARCC exam, it is important to consider these results through the lens of the goals that the policy sought to achieve. The goal of the Algebra in eighth grade policy was not to improve student performance on the Algebra 1 assessment. In fact, there was likely an acknowledgment prior to the policy adoption that performance on the Algebra 1 assessment may decrease, since the students have one year less of foundational math. The goal of the policy was to increase student enrollment in advanced math courses, which requires students to complete Algebra at a younger age as well as be successful in Algebra so that they can succeed in subsequent courses. In this context, it is apparent that a non-significant or a significant but small effect indicates that the policy is accomplishing its aim to accelerate students successfully through the math curriculum. Since New Jersey law requires high school students to take and pass three math courses at the high school level, students who were exposed to the policy are subsequently required to take at least one year of advanced math (Geometry, Algebra 2 and one additional course), which has the effect of nearly doubling student participation in higher level math courses in high school. Although the students who were exposed to the policy saw a decrease in their performance, with only 2.04% of the variance being explained by the policy, the results indicate that the policy's benefit of increasing participation in advanced math outweighs the nominal decrease of performance in Algebra 1. Additionally, since attendance was found to be the strongest predictive variable in the model, schools may be able to leverage policies intended to improve attendance enough to offset the negative effect of the policy on performance.

Research Question 2: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

Answer: A hierarchical regression was run including five independent variables (treatment, gender, race, prior achievement, and attendance) only on students enrolled in the free and reduced lunch program, and therefore identified as economically disadvantaged, to identify the effect of this variable on student performance on the Algebra 1 PARCC exam. Non-significant variables were excluded from subsequent models, leaving a final model with only statistically significant variables included. Exposure to the "algebra for all students in eighth grade" policy did not have a statistically significant effect on economically disadvantaged students' performance on the Algebra PARCC exam:

Table 83: Reported Results for Research Question 2

	Treatment	Gender	Race	Prior Achievement	Attendance
Standardized Beta Values			.337	.341	-.309
Percent of Variance Explained			11.35%	11.63%	9.56%

Gender also had no effect on the economically disadvantaged cohort's performance on the Algebra 1 PARCC exam. Prior achievement and race were both comparably strong in explaining variance in student achievement in Algebra 1. Students who identified as black and/or Hispanic performed better than other students who were also economically disadvantaged. Economically disadvantaged students who performed better prior to Algebra 1 continued to perform better in Algebra 1. As with all the other subgroups in the Algebra performance analysis, lower attendance rates continued to be associated with poorer performance on the Algebra 1 PARCC exam.

Once again, the fact that exposure to the "algebra for all" in eighth grade policy had no effect on Algebra 1 performance for this subgroup demonstrates that the policy has, in part, accomplished its goal of having students successfully complete Algebra prior to the ninth grade. Interestingly, this was the only subgroup in the entire study that was affected by race. The effect of race was contrary to prior research, demonstrating that black and Hispanic students perform worse than their peers in math (Harris & Herrington, 2006; Phillips et al., 1998; Shelly, 2009). This effect, however, disappeared when performance on the Geometry assessment was analyzed. Prior achievement and attendance affected student performance in a predictable direction. Students who entered Algebra with a history of higher performance continued to perform better than their peers, and students with better attendance during Algebra continued to perform better than their peers.

Research Question 3: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

Answer: Only students who self-identified as black and Hispanic were included. A hierarchical regression was run on the remaining five independent variables in the study (treatment, gender, socioeconomic status, prior achievement, and attendance) in order to identify the effect of the policy when these other factors on the Algebra 1 PARCC exam were controlled for. The regression was run including all independent variables in the first model and excluding those that were found to be non-significant until only significant variables remained. The resultant model, including only significant variables, indicates that the "algebra for all students in the eighth grade" policy had a positive effect on black or Hispanic students' performance:

Table 84: Reported Results for Research Question 3

	Treatment	Gender	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values	.222		.296	.421	-.387
Percent of Variance Explained	4.92%		8.76%	17.72%	14.98%

The gender of black and Hispanic students had no effect on their performance on the Algebra 1 PARCC exam. Attendance and prior achievement continued to be the strongest predictors of performance on the assessment. Being economically disadvantaged also had a statistically significant effect on performance by black and Hispanic students on the Algebra 1 PARCC exam but in an unpredictable direction. Students who were identified as economically disadvantaged actually performed better in this subgroup than their non-economically disadvantaged peers.

This subgroup represented the only group of students in the study who demonstrated an improvement in their performance on the assessment as a result of being exposed to the policy. This outcome was surprising as the adoption of the policy did not intend to improve student performance on the Algebra 1 assessment. It is possible that similar to Burris and Garrity's (2008) conclusions on the effects of tracking, the structure in place prior to the "algebra for all" in eighth grade policy resulted in black and Hispanic students being tracked into the lower, Math 8, class unlike their peers of other races. Exposure to more rigorous coursework was a more appropriate setting for these students, which resulted in them performing better, perhaps due to a more challenging, less boring setting (Loveless, 2009).

Research Question 4: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

Answer: A hierarchical regression was run on all female students in the two treatment cohorts, including the five independent variables other than gender in the study (treatment, race, socioeconomic status, prior achievement, and attendance) to predict the dependent variable: Algebra 1 PARCC performance. The first model included all of the independent variables, and subsequent models removed non-significant variables until only significant factors remained. The results of this analysis indicate that the adoption of the "algebra for all" in eighth grade policy had no effect on female students' achievement:

Table 85: Reported Results for Research Question 4

	Treatment	Race	Socioeconomic Status	Prior Achievement	Attendance

Standardized Beta Values			.217	.232	-.379
Percent of Variance Explained			4.71%	5.38%	15.76%

Race also had no effect on female student performance on the Algebra 1 PARCC exam. Attendance was, again, the strongest predictor of Algebra 1 performance in the female subgroup, explaining 15.76% of the variance in achievement. Being economically disadvantaged had a small, but positive impact on this subgroup's achievement.

The results of the hierarchical regression analysis on female performance on the Algebra 1 PARCC Assessment support the implementation of the Algebra in eighth grade policy in that the policy had no effect on student achievement. Again, this implies that more members of this subgroup are going to have access to higher level math based on their earlier completion of Algebra 1, compared to their peers in the other cohort. Since performance in Algebra was not affected, the intent of the policy to accelerate students without compromising their foundation was realized.

Research Question 5: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performance on the Algebra 1 PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was run including male members from both treatment cohorts. The five independent variables other than gender (treatment, race, socioeconomic status, prior achievement, and attendance) were all included in the initial model to predict student performance on the Algebra 1 PARCC exam. Subsequent models excluded variables that were found to be non-significant until only significant variables remained. The results of this analysis demonstrate that the adoption of the “algebra for all” in eighth grade had no effect on males’ performance on the Algebra 1 PARCC Assessment:

Table 86: Reported Results for Research Question 5

	Treatment	Race	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values					-.270
Percent of Variance Explained					7.29%

The only variable included in the study that had any effect on achievement in Algebra by this subgroup was attendance. Predictably, students with more absences performed poorer than students with less absences during the Algebra 1 course. The lack of any effect realized by treatment exposure indicates that the policy of requiring Algebra of all students in the eighth grade had the desired effect of successfully accelerating the math curriculum for boys in this cohort.

Conclusions: Effect of Treatment on Algebra 1 Performance

A review of the statistical analyses of all students and student subgroups’ performance on the Algebra 1 assessment indicates that the “algebra for all students in eighth-grade policy” has a nominal effect, if any, on achievement. The full cohort realized a slight decrease in performance. However, the only subgroup that was affected in any way was black and Hispanic students, who actually performed better than their Math 8 counterparts. Prior achievement and attendance were found to be the most powerful predictors of performance on Algebra 1 PARCC Assessment. In all but one case (prior achievement in males), these two variables had a statistically significant effect on student outcomes. In all cases, one of these two variables was the strongest predictor of any variable included in the study, explaining variance in outcomes.

Research questions six through ten address the effect of the policy on "future" achievement, measured by students' achievement in Geometry.

Research Question 6: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect future student achievement, measured by their performance on the Geometry PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was performed on all students in the study and included six independent variables (treatment, gender, race, socioeconomic status, prior achievement, and attendance) to predict the dependent variable of future math achievement in Geometry, which is the next course students enroll in upon successful completion of Algebra 1. Achievement in Geometry was measured by students' performance on the Geometry end-of-year PARCC assessment. All of the variables were included in the initial model. Subsequent models dropped non-significant variables until a final model, including only significant variables, could be analyzed. The results of this analysis indicate that the "algebra for all" in eighth grade policy had no effect on student performance in Geometry:

Table 87: Reported Results for Research Question 6

	Treatment	Gender	Race	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values					.206	-.196
Percent of Variance Explained					4.24%	3.84%

Gender, race, and socioeconomic status also have no effect on students' future achievement, measured as their performance on the Geometry PARCC Assessment. Prior achievement and attendance were the only two variables identified as having a statistically significant effect on student performance in Geometry. The effect of both variables was predictable: higher prior achievement and better attendance both resulted in higher achievement in Geometry (and vice versa). The fact that treatment status did not affect students' performance in Geometry continues to support the success of the policy. Students are performing as well as they had been in Geometry but are completing the courses one year earlier than they would have otherwise.

Research Question 7: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect the future achievement of economically disadvantaged (enrolled in free and reduced lunch) students, measured by their performance on the Geometry PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was run including only the members of the two treatment cohorts who were enrolled in the free and reduced lunch program, and therefore were classified as economically disadvantaged. The five independent variables (treatment, gender, race, prior achievement, and attendance) other than socioeconomic status were included in the analysis to determine their effect on students' performance on the Geometry PARCC Assessment. The analysis began with all the variables included, dropping non-significant variables in subsequent models until only significant variables remained. The results of this analysis indicate that the "algebra for all students in eighth grade" policy has no effect on economically disadvantaged students' achievement in Geometry. Furthermore, no variable included in the study had any effect on students' performance on the Geometry assessment. The lack of any identifiable effect of treatment status on outcomes for the economically disadvantaged subgroup indicates that these students are performing as well in Geometry as they would have otherwise. It is interesting to note, however, that neither prior achievement nor attendance have an effect on these students' performance, as at least one of those two variables had a measurable effect on every other subgroup that was included in the study.

Research Question 8: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect black and Hispanic students' achievement, measured by their performance on the Geometry PARCC end-of-course assessment?

Answer: The hierarchical regression that was performed to answer this question included the five applicable independent variables being studied (treatment, gender, socioeconomic status, prior achievement, and attendance). An initial model was run including all variables, and subsequent models removed variables until only statistically significant explanatory variables remained. The results of this analysis indicated that a student's exposure to the Algebra in eighth grade policy has no effect on their achievement in Geometry:

Table 88: Reported Results for Research Question 8

	Treatment	Gender	Race	Prior Achievement	Attendance
Standardized Beta Values				.272	
Percent of Variance Explained				7.40%	

Gender, race, and attendance were also found to have no effect on back and Hispanic students' achievement in Geometry. Prior achievement was the only statistically significant explanatory variable included in this analysis. Again, the lack of a negative effect of treatment status is an indication that the policy enrolling all eighth grade students in Algebra 1 was successful for this subgroup, as they have completed Algebra one year earlier than they would have if the policy were not in place, and their success in their future math classes was not jeopardized.

Research Question 9: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect female students' achievement, measured by their performances on the Geometry PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was run on only the female members of both treatment cohorts. The five independent variables, other than gender, (treatment, race, socioeconomic status, prior achievement, and attendance) were included in the initial model, and subsequent models excluded non-significant variables until only significant variables remained. The results of this analysis indicated that the exposure of female students to the "algebra for all students in eighth grade" policy had no effect on their performance in Geometry the following year:

Table 89: Reported Results for Research Question 9

	Treatment	Race	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values				.268	
Percent of Variance Explained				7.18%	

Race, socioeconomic status, and attendance also had no effect on female students' performance in Geometry. Prior achievement was the only statistically significant variable in the analysis, accounting for 7.18% of the variance in females' scores on the Geometry assessment. Once again, the lack of an effect of the treatment status variable indicates the effective implementation of the "algebra for all students in eighth grade" policy, as female students are moving more quickly through the curriculum without seeing a decrease in performance.

Research Question 10: How does the shift from offering Algebra as an advanced eighth-grade course to mandating it universally as the standard eighth-grade math course affect male students' achievement, measured by their performances on the Geometry PARCC end-of-course assessment?

Answer: A hierarchical regression analysis was run on males only in each treatment cohort. All independent variables, excluding gender, (treatment, socioeconomic status, race, prior achievement and attendance) were included in the initial model, and subsequently excluded in following models if they were found to be statistically non-significant. The results of this analysis indicate that the implementation of an “algebra for all students in eighth grade” policy had no effect on male students’ performance on the Geometry PARCC Assessment:

Table 90: Reported Results for Research Question 10

	Treatment	Race	Socioeconomic Status	Prior Achievement	Attendance
Standardized Beta Values				.200	-.205
Percent of Variance Explained				4.00%	4.20%

Race and socioeconomic status were also found to be non-significant in predicting males’ performance on the Geometry PARCC Assessment. Prior achievement and attendance were both found to be statistically significant, although the effect was relatively small, explaining only 4.00% and 4.20% of the variance in scores, respectively. There was no effect resulting from the treatment variable, indicating that the “algebra for all students in eighth grade” policy met its goal of accelerating male students through the K-12 math curriculum without undermining their foundational math development.

Conclusions: Effect of Treatment on Geometry Performance

A review of the statistical analyses of all student and student subgroup performance on the Geometry PARCC Assessment indicates that exposure to the “algebra for all students in eighth grade” policy has no effect on students’ future math performance. There were no differences in performance between the two treatment cohorts in the full cohort and all subgroup performance analyses. As in the analysis of performance in Algebra, prior achievement and attendance proved to be the most meaningful predictors. However, these variables’ strength was much less pronounced when student performance in Geometry was measured. Prior achievement was statistically significant in all subgroups except for economically disadvantaged students. Attendance was only significant in predicting performance in the whole cohort and in males.

Recommendations for Policy

When developing policy regarding the pacing and structure of the K-12 math curriculum, it is essential for policy members and stakeholders to have a clear understanding of what their intended outcome is. In the case studied, the intent of the "algebra for all students in eighth grade" policy was to increase student participation in advanced math courses in the 11th grade. These students would have already completed the core math courses of Algebra 1, Geometry, and Algebra 2. This policy sought to achieve this goal without compromising students' understanding of the foundational skills taught in these three courses, which are essential for success in advanced math. The previous pacing of the curriculum would have these students only eligible for advanced math courses in the 12th grade, since they would not be taking Algebra 1 until ninth grade. The risk of adopting a policy such as this one is that students have one less year of math prior to entering Algebra 1 and are therefore not adequately prepared for success in this course. Research has demonstrated that students who do not succeed in Algebra 1 during their first attempt and have to retake it perform worse in all levels of math compared to their peers who waited an extra year to take Algebra 1 in the first place, even though they take the courses at the same time (Gamoran & Hannigan, 2000).

An analysis of this study through the lens of the intentions of policy makers indicates that the shift from Algebra 1 in the ninth grade to Algebra 1 in the 10th grade was successful in increasing access to advanced math without compromising performance in foundational math, specifically Algebra 1 and Geometry. The treatment had a small negative effect on student performance for the whole cohort taking Algebra 1 in the eighth grade (standardized beta of -.143). The variance explained by the adoption of this policy only explained 2.04% of the variance in scores, indicating that there are other factors contributing to student performance that may be able to offset these modest losses. Additionally, one subgroup, black and Hispanic students, actually saw an increase in performance in Algebra 1. This was a surprising result because the intent of the policy was not to improve Algebra 1 performance, and there was no reason to believe that offering students Algebra 1 with one less year of math instruction would result in better performance in that course. No other subgroup (economically disadvantaged students, males, or females) saw a similar effect on their performance in Algebra 1 as a result of the policy.

One potential downside of the policy is that students have less foundational skills than they would have if they took eight years of sub-high-school math, and this may affect their readiness for advanced math all together. The policy, by default, increases the number of students enrolled in advanced math, since students are required to complete three years of math in high school, and Algebra 2 becomes students' second course. The goal of the policy, however, was to increase this enrollment without compromising students' ability to be successful in advanced math. In the context of this study, future math achievement was measured by students' performance in Geometry, the first course students take after they are affected by the policy when enrolled in eighth grade. The results of the study indicate that there was no detectable effect of the policy on achievement in Geometry for all students or for any subgroup that was examined. Again, this supports the policy as being successful, since student success in future math was not compromised, and enrollment in advanced math will eventually increase as a result.

Although this study demonstrates that the policy was successful in the short term, it is important for policymakers and other decisions makers to consider the limitations. This study only examined students during the first two years of what will potentially be a five-year sequence of high school math courses. The policy was found to have limited negative effects on performance in Algebra 1 and no effect on performance in Geometry. However, decision-makers must also consider the effect of this policy on Algebra 2 and other advanced math courses that all students would then be exposed to.

Policy makers may also want to consider some of the secondary findings of this study, outside of the effect of the Algebra in eighth grade policy, to inform their decision making. Prior achievement and attendance were persistently the strongest variables in predicting student achievement in both Algebra 1 and Geometry. The directionality of these variables' effects was predictable: students with lower attendance rates performed worse (and vice versa), and students with higher prior achievement performed better (and vice versa). That being said, some of the negative effects of the policy, in particular the small drop in performance in Algebra 1 by the full cohorts, could be mitigated by other external policies aimed at improving attendance and bolstering student performance in math prior to enrollment in Algebra 1.

Recommendations for Practice

The success of an Algebra for all students in eighth grade policy relies on a well-articulated curriculum that does not support the acceleration of students in the lower grade levels. Although students will no longer be enrolled in eighth grade math, they still must have the standards that are traditionally taught at this level mastered in order to be primed for success in Algebra. Practitioners, and in particular, teachers and administrators dealing with students in grades kindergarten through seven, must have a clear understanding of where these students need to be in terms of their understanding of mathematics when they reach the eighth-grade Algebra 1 curriculum. Prior achievement was one of the strongest variables in predicting these students' performance, indicating that building a strong foundation is essential to the success of the policy.

In the same vain, as lower grade teachers, eighth grade Algebra 1 teachers and subsequent Geometry and Algebra 2 teachers must hold students responsible for meeting the now higher standards called for in these high school courses. Although these teachers may have spent their whole careers teaching sub-Algebra, middle school math, performance in Algebra 1 is linked to performance in all higher levels of math (Finkelstein & Snipes, 2015). Teachers must be made aware of the new, more complex, standards that their students have to meet as well as be adequately trained and prepared to teach a high school level course. Maintenance of the level of rigor in Algebra 1, Geometry, and Algebra 2, with the bulk of students being one year younger, is essential to student success in advanced math.

Recommendation for Future Study

The nature of this study presents two major limitations with regard to analyzing the success of the "algebra for all students in eighth grade" policy. The first limitation is found in the limited longevity of the study. The indication of the success of the policy in the conclusions is limited to a description of increased student participation in advanced math courses, and not necessarily success in advanced math courses. The additional, longer-term goal of the policy is to graduate more students from high school who are prepared for future study and possibly careers in math-related majors and fields. Future researchers can further investigate the effectiveness of the policy by applying similar research techniques to determine the policy's effect on student performance in Algebra 2 and other advanced math courses. The second major limitation is the limited population of the study, as the study was confined to only investigating Fort Lee students who represent a unique demographic in New Jersey. Specific recommendations for how these limitations can be addressed, as well as how the study can be further refined and built on by future researchers are listed below:

- Replicate this study in contexts other than Fort Lee to see how the "algebra for all students in eighth grade policy" performs with different demographics.
- Replicate this study with a larger sample size, in particular when examining subgroups.
- Conduct a study examining student performance at all grade levels leading up to the eighth grade in order to identify possible opportunities for improving prior achievement.
- Conduct a study identifying the effects of the "algebra for all students in eighth grade" policy on performance in Algebra 2.
- Conduct a study identifying the effects of the algebra for all students in eighth grade on performance in advanced math courses including pre-calculus and other courses taken after Algebra 2 that were previously unavailable to students.
- Conduct a longitudinal study examining the effect of the policy on students' acceptance to college and other programs.
- Conduct a longitudinal study examining student success in mathematics through college.
- Conduct a study examining the effect of the policy on students' determination of college majors and career pursuits.

- Conduct a study examining possible reasons why black and Hispanic students reported the anomalous outcome of an improvement in Algebra 1 as a result of the adoption of the "algebra for all students in eighth grade" policy.
- Conduct a study examining teacher job satisfaction and performance across the grade levels affected by the study.
- Conduct a study identifying the actionable factors affecting student attendance of school.

Conclusion

The adoption of the "algebra for all students in eighth grade" policy by the Fort Lee Public Schools was a success in terms of the scope of this study. The policy had a negative, but small effect on student performance in Algebra 1. The policy had no effect on student performance in Geometry. The conclusion that can be drawn from this data is that the policy has successfully accelerated the students in the K-12 math curriculum by one year without compromising their ability to perform in Algebra 1 or Geometry.

The strongest effects identified by the study were caused by variables other than the policy adoption, namely attendance and prior achievement. School districts and policy makers may wish to use these findings to target students with poor attendance or performance at younger grade levels in order to improve these measures and subsequently improve performance in Algebra 1 and Geometry.

Several sub-questions researched are limited in their ability to explain outcomes due to low sample sizes. These questions include research question 2 (economically disadvantaged students' performance in Algebra), research question 3 (black and Hispanic students' performance in Algebra), research question 7 (economically disadvantaged students' performance in Geometry), research question 8 (black and Hispanic students' performance in Geometry), and research question 9 (female students' performance in Geometry). Conclusions that can be made on these specific subgroups are limited as the sample sizes do not meet Field's (2013) threshold of 104 + k.

Based on these findings, it is recommended that districts that are comparable to Fort Lee consider adopting an "algebra for all students in eighth grade" policy in order to advance their students through the math curriculum faster, allowing them to access more advanced math courses. Districts considering these policies should perform a thoughtful curriculum audit and articulation that ensures students are prepared for Algebra 1 when they are enrolled at a younger age. Furthermore, they should conduct ongoing data analysis of student performance on the advanced math curriculum to address any significant dips in performance that may arise due to the acceleration. So long as the adoption of the "algebra for all students in eighth grade" policy is implemented under these conditions, the results of this study indicate that it is an effective means of increasing student enrollment in advanced math courses in a school district.

REFERENCE LIST

Achieve (2013). Advanced Math Equals Career Readiness. Math Works. Retrieved from https://www.achieve.org/files/MathWorks-AllStudentsNeedAdvancedMath_0.pdf

Adelman, C. (2006). *The Toolbox Revisited: Paths to Degree Completion from High School through College*. Washington, DC: U.S. Department of Education.

Arens, A. K., Marsh, H. W., Pekrun, R., Lichtenfeld, S., Murayama, K., & vom Hofe, R. (2017). Math self-concept, grades, and achievement test scores: Long-term reciprocal effects across five waves and three achievement tracks. *Journal of Educational Psychology, 109*(5), 621-634. doi:10.1037/edu0000163

Aughinbaugh, A. (2012). The effects of high school math curriculum on college attendance: Evidence from the NLSY97. *Economics of Education Review*, *31*(6), 861-870. doi:10.1016/j.econedurev.2012.06.004

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America, 107,* 1860–1863. doi:10.1073/pnas.0910967107

Borman, G., & Dowling, M. (2010). Schools and inequality: A multilevel analysis of Coleman's Equality of Educational Opportunity data. *Teachers College Record, 112*, 1201–1246.

Bozick, R., & Ingels, S. J. (2008). Mathematics Coursetaking and Achievement at the End of High School: Evidence from the Education Longitudinal Study of 2002 (ELS:2002). Statistical Analysis Report. Retrieved from https://nces.ed.gov/pubs2008/els_hsmath/index.asp

Burris, C. C., & Garrity, D. T. (2008). *Detracking for Excellence and Equity*. Alexandria, VA: Assoc. for Supervision and Curriculum Development.

Carnevale, A. P., & Desrochers, D. M. (2003). The democratization of mathematics. In B. L. Madison, & L. A. Steen (Eds.), *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges* (pp. 21-31).

Casad, B. J., Hale, P., & Wachs, F. L. (2015). Parent-child math anxiety and math-gender stereotypes predict adolescents' math education outcomes. *Frontiers in Psychology, 6*, 1597.

Cheryan, S. (2012). Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not? *Sex Roles*, *66*, 184–190. doi: 10.1007/s11199-011-0060-z

Civil Rights Data Collection. (2012). The Civil Rights Data Collection Summary. Retrieved from http://www2.ed.gov/about/offices/list/ocr/docs/crdc-2012-data-summary.pdf

College Board. (2007). *2007 College-Bound Seniors: Total Group Profile Report: Total Group*. New York, NY: College Board.

Diaz, V. (2008). Relationships between district size, socioeconomics, expenditures, and student achievement in Washington. *Rural Educator*, *29*, 30 –39.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). Los Angeles, CA: Sage Publications.

Gamoran, A., & Hannigan, E.C., (2000). Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school. *Educational Evaluation and Policy Analysis, 22*(3), 241–254.

Goodman, J. (2009). The Labor of Division: Returns to Compulsory Math Coursework. Retrieved from http://isites.harvard.edu/fs/docs/icb.topic630262.files/NBER_EducGroup.pdf

Harris, D. N., & Herrington, C. D. (2006). Accountability, standards, and the growing achievement gap: Lessons from the past half century. *American Journal of Education, 112*, 209–238.

Hattie, J. (2005). The paradox of reducing class size and improving learning outcomes. *International Journal of Educational Research, 43*, 387–425. doi:10.1016/j.ijer.2006.07.002

Hembree, R. (1990). The Nature, Effects, and Relief of Mathematics Anxiety. *Journal for Research in Mathematics Education, 1*, 33. doi:10.2307/749455

Howard, K. A., Scott, A., Romero, M., & Saddler, D. (2015). Success after Failure: Academic Effects and Psychological Implications of Early Universal Algebra Policies. *Journal of Urban Mathematics Education, 8*(1), 31-61.

Loveless, T., Thomas, B., & Fordham I. (2009). Tracking and Detracking: High Achievers in Massachusetts Middle Schools. Retrieved from https://edexcellence.net/publications/tracking-and-detracking-high.html?v=publication

Marsh, H. W. (2007). *Self-concept theory, measurement and research into practice: The role of Self-concept in educational psychology*. Leicester, UK: British Psychological Society.

National Center for Education Statistics. (2012). *High School Coursetaking: Findings from The Condition of Education 2012*. Washington, DC: U.S. Department of Education.

Nomi, T., & Allensworth. E. (2014). Skill-Based Sorting in the Era of College Prep for All: Costs and Benefits. Retrieved from https://consortium.uchicago.edu/sites/default/files/publications/Sorting%20Brief.pdf

Paglin, M., & Rufolo, A. M. (1990). Heterogenous Human Capital, Occupational Choice, and Male-Female Earnings Differences. *Journal of Labor Economics, 8*(1), 123-44.

Phillips, M., Crouse, J., & Ralph, J. (1998). Does the Black–White test score gap widen after children enter school? In C. Jencks, & M. Phillips (Eds.), *The Black–White test score gap* (pp. 229–271). Washington, DC: Brookings.

Rose, H., & Betts, J. R. (2004). The effect of high school courses on earnings. *Review of Economics and Statistics, 86*(2), 497-513.

Rubin, B. C. (2003). Unpacking Detracking: When Progressive Pedagogy Meets Students' Social Worlds. *American Educational Research Journal, 2*, 539.

Rubin, B. C. (2006). Tracking and Detracking: Debates, Evidence, and Best Practices for a Heterogeneous World. *Theory into Practice*, *45*(1), 4-14. doi:10.1207/s15430421tip4501_2

Shelly, B. (2009). School Effects: Examining the Race Gap in Mathematics Achievement. *Journal of African American Studies, 4*, 388.

Sirin, S. (2005). Socioeconomic Status and Academic Achievement: A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417-453.

Snipes, J., & Finkelstein, N. (2015). Opening a Gateway to College Access: Algebra at the Right Time. Retrieved from https://eric.ed.gov/?id=ED559739

White, G. W., Stepney, C. T., Hatchimonji, D. R., Moceri, D. C., Linsky, A. V., Reyes-Portillo, J. A., & Elias, M. J. (2016). The increasing impact of socioeconomics and race on standardized academic test scores across elementary, middle, and high school. *American Journal of Orthopsychiatry*, *86*(1), 10-23. doi:10.1037/ort0000122

Williams, T., Haertel, E., & Kirst, M. W. (2011). Improving Middle Grades Math Performance: A Closer Look at District and School Policies and Practices, Course Placements, and Student Outcomes in California. Retrieved from https://eric.ed.gov/?id=ED516658

Welner, K., & Burris, C. C. (2006). Alternative Approaches to the Politics of Detacking. *Theory into Practice*, *45*(1), 90-99. doi:10.1207/s15430421tip4501_12.

Worthy, J. (2010). Only the Names Have Been Changed: Ability Grouping Revisited. *Urban Review*, *42*(4), 271-295. doi:10.1007/s11256-009-0134-1

APPENDIX A – ANOVA Table (Research Question 1)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	48413.468	6	8068.911	8.004	.000[b]
	Residual	239943.210	238	1008.165		
	Total	288356.678	244			
2	Regression	47921.510	5	9584.302	9.527	.000[c]
	Residual	240435.168	239	1006.005		
	Total	288356.678	244			
3	Regression	47087.884	4	11771.971	11.710	.000[d]
	Residual	241268.794	240	1005.287		
	Total	288356.678	244			
4	Regression	45159.361	3	15053.120	14.917	.000[e]
	Residual	243197.316	241	1009.117		
	Total	288356.678	244			

a. Dependent Variable: AlgebraAchievement

b. Predictors: (Constant), Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, EconDisadDummy, TreatmentStatus, PriorAchievement, BlackHispanicDummy

d. Predictors: (Constant), Attendance, EconDisadDummy, TreatmentStatus, PriorAchievement

e. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

APPENDIX B – ANOVA Table (Research Question 2)

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15207.675	5	3041.535	3.364	.010[b]
	Residual	50637.421	56	904.240		
	Total	65845.097	61			
2	Regression	13252.226	4	3313.057	3.591	.011[c]
	Residual	52592.870	57	922.682		
	Total	65845.097	61			
3	Regression	13184.688	3	4394.896	4.841	.004[d]
	Residual	52660.409	58	907.938		
	Total	65845.097	61			

a. Dependent Variable: AlgebraAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, SexDummy, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement, BlackHispanicDummy

d. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy

APPENDIX C – ANOVA Table (Research Question 3)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42335.648	5	8467.130	11.837	.000[b]
	Residual	45064.787	63	715.314		
	Total	87400.435	68			
2	Regression	42283.349	4	10570.837	14.995	.000[c]
	Residual	45117.086	64	704.954		
	Total	87400.435	68			

a. Dependent Variable: AlgebraAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, SexDummy, PriorAchievement

c. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

APPENDIX D – ANOVA Table (Research Question 4)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36467.987	5	7293.597	8.059	.000[b]
	Residual	99547.073	110	904.973		
	Total	136015.060	115			
2	Regression	36456.655	4	9114.164	10.162	.000[c]
	Residual	99558.406	111	896.923		
	Total	136015.060	115			
3	Regression	34736.626	3	11578.875	12.805	.000[d]
	Residual	101278.434	112	904.272		
	Total	136015.060	115			

a. Dependent Variable: AlgebraAchievement

b. Predictors: (Constant), Attendance, BlackHispanicDummy, TreatmentStatus, EconDisadDummy, PriorAchievement

c. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

d. Predictors: (Constant), Attendance, EconDisadDummy, PriorAchievement

APPENDIX E – ANOVA Table (Research Question 5)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18475.625	5	3695.125	3.416	.006[b]
	Residual	133033.274	123	1081.571		
	Total	151508.899	128			
2	Regression	18330.734	4	4582.684	4.267	.003[c]
	Residual	133178.165	124	1074.017		
	Total	151508.899	128			
3	Regression	17482.662	3	5827.554	5.435	.002[d]
	Residual	134026.237	125	1072.210		
	Total	151508.899	128			
4	Regression	14583.117	2	7291.558	6.710	.002[e]
	Residual	136925.783	126	1086.713		
	Total	151508.899	128			
5	Regression	12328.424	1	12328.424	11.249	.001[f]
	Residual	139180.475	127	1095.909		
	Total	151508.899	128			

a. Dependent Variable: AlgebraAchievement

b. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy, EconDisadDummy, TreatmentStatus

c. Predictors: (Constant), Attendance, PriorAchievement, BlackHispanicDummy, TreatmentStatus

d. Predictors: (Constant), Attendance, PriorAchievement, TreatmentStatus

e. Predictors: (Constant), Attendance, TreatmentStatus

f. Predictors: (Constant), Attendance

APPENDIX F – ANOVA Table (Research Question 6)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25290.441	6	4215.074	4.504	.000[b]
	Residual	204013.808	218	935.843		
	Total	229304.249	224			
2	Regression	24643.401	5	4928.680	5.274	.000[c]
	Residual	204660.848	219	934.524		
	Total	229304.249	224			
3	Regression	24159.362	4	6039.840	6.477	.000[d]
	Residual	205144.887	220	932.477		
	Total	229304.249	224			
4	Regression	23123.734	3	7707.911	8.262	.000[e]
	Residual	206180.515	221	932.944		
	Total	229304.249	224			
5	Regression	22293.378	2	11146.689	11.954	.000[f]
	Residual	207010.871	222	932.481		
	Total	229304.249	224			

a. Dependent Variable: GeometryAchievement

b. Predictors: (Constant), BlackHispanicDummy, SexDummy, TreatmentStatus, Attendance, PriorAchievement, EconDisadDummy

c. Predictors: (Constant), SexDummy, TreatmentStatus, Attendance, PriorAchievement, EconDisadDummy

d. Predictors: (Constant), SexDummy, TreatmentStatus, Attendance, PriorAchievement

e. Predictors: (Constant), TreatmentStatus, Attendance, PriorAchievement

f. Predictors: (Constant), Attendance, PriorAchievement

APPENDIX G – ANOVA Table (Research Question 7)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9793.371	5	1958.674	1.588	.179[b]
	Residual	66589.562	54	1233.140		
	Total	76382.933	59			
2	Regression	9645.205	4	2411.301	1.987	.109[c]
	Residual	66737.729	55	1213.413		
	Total	76382.933	59			
3	Regression	9278.810	3	3092.937	2.581	.062[d]
	Residual	67104.123	56	1198.288		
	Total	76382.933	59			
4	Regression	7583.978	2	3791.989	3.142	.051[e]
	Residual	68798.955	57	1206.999		
	Total	76382.933	59			
5	Regression	4119.410	1	4119.410	3.306	.074[f]
	Residual	72263.523	58	1245.923		
	Total	76382.933	59			

a. Dependent Variable: GeometryAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, SexDummy, BlackHispanicDummy, PriorAchievement

c. Predictors: (Constant), Attendance, TreatmentStatus, BlackHispanicDummy, PriorAchievement

d. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

e. Predictors: (Constant), Attendance, TreatmentStatus

f. Predictors: (Constant), Attendance

APPENDIX H – ANOVA Table (Research Question 8)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8439.278	5	1687.856	1.823	.123[b]
	Residual	51838.932	56	925.695		
	Total	60278.210	61			
2	Regression	8269.070	4	2067.267	2.266	.073[c]
	Residual	52009.140	57	912.441		
	Total	60278.210	61			
3	Regression	8057.746	3	2685.915	2.983	.039[d]
	Residual	52220.464	58	900.353		
	Total	60278.210	61			
4	Regression	7808.181	2	3904.090	4.390	.017[e]
	Residual	52470.029	59	889.323		
	Total	60278.210	61			
5	Regression	4474.415	1	4474.415	4.811	.032[f]
	Residual	55803.795	60	930.063		
	Total	60278.210	61			

a. Dependent Variable: GeometryAchievement

b. Predictors: (Constant), Attendance, EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement

c. Predictors: (Constant), EconDisadDummy, SexDummy, TreatmentStatus, PriorAchievement

d. Predictors: (Constant), EconDisadDummy, TreatmentStatus, PriorAchievement

e. Predictors: (Constant), TreatmentStatus, PriorAchievement

f. Predictors: (Constant), PriorAchievement

APPENDIX I – ANOVA Table (Research Question 9)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13475.005	5	2695.001	2.903	.017[b]
	Residual	90980.649	98	928.374		
	Total	104455.654	103			
2	Regression	12525.982	4	3131.495	3.372	.012[c]
	Residual	91929.672	99	928.583		
	Total	104455.654	103			
3	Regression	10843.228	3	3614.409	3.861	.012[d]
	Residual	93612.426	100	936.124		
	Total	104455.654	103			
4	Regression	7686.411	2	3843.205	4.011	.021[e]
	Residual	96769.243	101	958.111		
	Total	104455.654	103			
5	Regression	7507.825	1	7507.825	7.899	.006[f]
	Residual	96947.829	102	950.469		
	Total	104455.654	103			

a. Dependent Variable: GeometryAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement

d. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

e. Predictors: (Constant), TreatmentStatus, PriorAchievement

f. Predictors: (Constant), PriorAchievement

APPENDIX J – ANOVA Table (Research Question 10)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13964.492	5	2792.898	2.928	.016[b]
	Residual	109675.343	115	953.699		
	Total	123639.835	120			
2	Regression	13956.387	4	3489.097	3.690	.007[c]
	Residual	109683.448	116	945.547		
	Total	123639.835	120			
3	Regression	13688.039	3	4562.680	4.855	.003[d]
	Residual	109951.796	117	939.759		
	Total	123639.835	120			
4	Regression	11243.144	2	5621.572	5.902	.004[e]
	Residual	112396.690	118	952.514		
	Total	123639.835	120			

a. Dependent Variable: GeometryAchievement

b. Predictors: (Constant), Attendance, TreatmentStatus, EconDisadDummy, PriorAchievement, BlackHispanicDummy

c. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement, BlackHispanicDummy

d. Predictors: (Constant), Attendance, TreatmentStatus, PriorAchievement

e. Predictors: (Constant), Attendance, PriorAchievement

APPENDIX K – IRB Approval

SETON HALL UNIVERSITY
1856

December 19, 2017

Peter Crawley
[redacted]

Dear Mr. Crawley,

The Seton Hall University Institutional Review Board has reviewed the information you have submitted addressing the concerns for your proposal entitled "The Effect of Mandating Algebra for all Students in Grade 8 versus Grade 9 in a Small Suburban K-12 School District in New Jersey." Your research protocol is hereby accepted as revised and is categorized as exempt.

Please note that, where applicable, subjects must sign and must be given a copy of the Seton Hall University current stamped Letter of Solicitation or Consent Form before the subjects' participation. All data, as well as the investigator's copies of the signed Consent Forms, must be retained by the principal investigator for a period of at least three years following the termination of the project.

Should you wish to make changes to the IRB approved procedures, the following materials must be submitted for IRB review and be approved by the IRB prior to being instituted:

- Description of proposed revisions;
- *If applicable*, any new or revised materials, such as recruitment fliers, letters to subjects, or consent documents; and
- *If applicable*, updated letters of approval from cooperating institutions and IRBs.

At the present time, there is no need for further action on your part with the IRB.

In harmony with federal regulations, none of the investigators or research staff involved in the study took part in the final decision.

Sincerely,

Mary F. Ruzicka, Ph.D.

Mary F. Ruzicka, Ph.D.
Professor
Director, Institutional Review Board

cc: Dr. Martin Finkelstein

Office of Institutional Review Board
Presidents Hall • 400 South Orange Avenue • South Orange, NJ 07079 • Tel: 973.313.6314 • Fax: 973.275.2361 • www.shu.edu

REQUEST FOR APPROVAL OF RESEARCH, DEMONSTRATION OR RELATED ACTIVITIES INVOLVING HUMAN SUBJECTS

All material must be typed.

PROJECT TITLE: The effect of mandating algebra for all students in grade 8 versus grade 9 in a small suburban K-12 School District

CERTIFICATION STATEMENT:

In making **this application,** I(we) certify that I(we) have read and understand the University's policies and procedures governing research, development, and related activities involving human subjects. I (we) shall comply with the letter and spirit of those policies. I(we) further acknowledge my(our) obligation to (1) obtain written approval of significant deviations from the originally-approved protocol BEFORE making those deviations, and (2) report immediately all adverse effects of the study on the subjects to the Director of the Institutional Review Board, Seton Hall University, South Orange, NJ 07079.

Peter Crawley — 10/25/2017

RESEARCHER(S) — DATE

Please print or type out names of **all researchers below signature.
Use separate sheet of paper, if necessary.**

My signature indicates that I have reviewed the attached materials of my student advisee and consider them to meet IRB standards.

Martin Finkelstein

RESEARCHER'S FACULTY ADVISOR [for student researchers only] — DATE

Please print or type out name below signature

The request for approval submitted by the above researcher(s) was considered by the IRB for Research Involving Human Subjects Research at the Dec 2017 meeting.

The application was approved ✓ not approved ___ by the Committee. Special conditions were _____ were not ✓ set by the IRB. (Any special conditions are described on the reverse side.)

Mary F. Ruzicka, Ph.D. — 12/19/17

DIRECTOR,
SETON HALL UNIVERSITY INSTITUTIONAL
REVIEW BOARD FOR HUMAN SUBJECTS RESEARCH — DATE

Seton Hall University
3/2005